Options and consequences for the allocation of allowances to electricity producers

Including considerations about
opportunity-costs
for other
energy-intensive products

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In search for a sustainable solution for the allocation of allowances to electricity producers, the functioning of the market and its consequences are evaluated for the following options:

- Cap & trade, as basis for comparison (the current method), and as alternatives:
- Skewed allocation, a lower allocation of allowances to electricity producers and a higher allocation to electricity users
- Auctioning, with and without revenue recycling
- Fuel-specific PSRs (Performance Standard Rate)
- PSR (uniform for fossil-fuelled electricity)

These options are evaluated and assessed against the intentions and requirements of the Directive emissions trading and derived from this against the EC Treaty, in particular the competition rules. The preferred solution should be robust and applicable not only to electricity but also to the main other products falling under the scheme of emissions trading. The main findings of this study are:

Present allocation rules based on cap & trade
The opportunity-cost principle causes windfall profits for electricity producers and loss of competitiveness for industrial users. Furthermore, cap & trade causes distortions of competition and it enhances frozen market shares. These shortcomings are assessed to be in conflict with the Directive and the EC Treaty. Further important shortcomings are that efficiency and innovation are not structurally stimulated. For example, combined heat & power (CHP) and zero emission power plants receive no sustainable structural stimulation and coal- and lignite-fired power plants are favoured too much leading to conflicts with the objective function, the objective to reduce emissions.

Skewed allocation
In this method fewer allowances are granted to electricity producers and – as compensation for windfall profits – more allowances are granted to the other sectors. But this compensation is linked to emissions and not to the use of electricity. As the electricity price increase remains intact, this compensation is also not correct in Member States with a significant share of nuclear and hydropower; furthermore the compensation is absent for sectors outside the trading scheme, such as aluminium. Skewed allocation means the continuation of cap & trade and therefore the fundamental shortcomings of cap & trade remain.
In sum, skewed allocation cannot be regarded as a structural solution.

Auctioning
Auctioning is often considered as an option to eliminate windfall profits. This option is in full agreement with the objective function, CHP and zero emission plants are clearly stimulated. But analysis shows that windfall profits are to a large extent not eliminated because about 45% of electricity in the EU-25 is generated by nuclear and renewables. In addition, auctioning is no solution to the loss of competitiveness of industrial users of energy. Auctioning is a good method, but only if applied globally.

Auctioning with revenue recycling
Both recycling to the users of electricity as well as to the producers are evaluated. The first option does not work. Recycling to producers may be feasible in theory, provided recycling per unit of electricity produced, but this system would be rather complicated and transaction costs would be high. Furthermore, deviations will occur if the realised production of fossil-fuelled electricity deviates for the ex-ante projections.

Fuel-specific PSRs (Performance Standard Rates)
Fuel-specific PSRs are contrary to the objective function. A first option is to apply fuel-specific PSRs when establishing the cap for each individual operator. But then the system is still cap & trade and windfall profits and other shortcomings of this system are still in place. The second option is to apply fuel-specific PSRs with ex-post control on the production. Under this option it is evaluated that both the markets for CO_2 as well as the market for electricity become chaotic. It will lead to extremely high CO_2-prices and to unpredictable prices for electricity, which often will be very high as well. In addition, the potential for fuel switch is lowered with at least 50%. Therefore, fuel-specific PSRs, either for ex-ante caps or with ex-post control, are no feasible solution.

PSR (Performance Standard Rate)
One single PSR with ex-post control of production for fossil-fuelled electricity gives a market functioning, which is equal to auctioning. Through ex-post control allowances are only granted according to an amount per unit of product that is actually produced. With PSR the average price increase of electricity becomes zero or in any case very low. Only the real cost for the carbon constraint is paid by the customers.

By small annual adjustment of the PSR the environmental outcome is ensured and leakage of emissions outside the EU is virtually eliminated. In addition, taking account of a contingency reserve for unforeseen growth of fossil-fuelled electricity means that the environmental outcome of the scheme is ensured. This contingency is in practice for example only 0.4%-0.6% over an entire trading period of five years and in any case much smaller than the reserves for new entrants.

PSR meets the requirement of undistorted competition as winners of market share are not penalised as under cap & trade. PSR supports also the effectiveness of the scheme because market share winners are often more efficient producers and PSR provides no barriers of entry for efficient new entrants. Therefore, PSR certainly complies with the competition rules of the EC Treaty for this important aspect.

PSR is argued to be feasible within the requirements of the Directive. Firstly, the allocation of allowances becomes conditional, the condition being that the forecasted production is met. This falls within the requirement of Annex III (10) in which it is stated that each national allocation plan shall contain a list of installations covered by the Directive with the quantities of allowances <u>intended</u> to be allocated to each. Secondly, the allocation become objective as required by article 9 by applying the same PSR for the same type of installations. In contrast, cap & trade can never be objective as it requires arbitrary decisions when establishing an ex-ante cap for each operator; usually historic emissions and are taken as a basis.

The PSR approach provides clear and unambiguous incentives for the introduction and use of efficient and innovative technologies, as requested by the Directive. For example, Combined Heat and Power (CHP) is structurally stimulated. This also means that current supporting schemes of Member States, often less stable – for example for CHP – can be terminated. This advantage coincides with the policy of the EU Commission and Member States to simplify and reduce the number of governmental regulations.

PSR clearly supports the aims of the Lisbon strategy as innovation and efficient growth is stimulated; frontrunners are rewarded unambiguously and PSR provides as stable and predictable business environment. Once introduced, companies can hardly imagine that after some years the legislator would return to cap & trade.

Practical methods are presented in this study how PSR can be easily implemented in the EU.

In sum, PSR is a robust solution that is feasible for electricity as well as for other main products falling under the scheme of emissions trading.

I Introduction

I.1 Alternative allocation options for cap & trade

Recently windfall profits for electricity producers induced by the European Union emissions trading scheme have arrived, a transfer of wealth from electricity users to electricity producers. This results in higher electricity prices and loss of competitiveness for electricity users. The allocation method – cap & trade, in which allowances are decoupled from the actual production – has caused this phenomenon through opportunity-costs; this will be elaborated in this paper for electricity as well as for other products in general.

In search for a sustainable solution for the allocation of allowances to electricity producers, the functioning of the market and its consequences are evaluated for the following options:

- Cap & trade, as basis for comparison (the current method), and as alternatives:
- Skewed allocation under cap & trade
- Auctioning with and without revenue recycling
- Fuel-specific PSRs (Performance Standard Rates for gas, oil, coal and lignite)
- PSR (one uniform PSR for fossil-fuelled electricity)

Skewed allocation under cap & trade, in which electricity producers receive fewer and other sectors receive more allowances is studied as the first alternative.
Auctioning, with and without revenue recycling, is another set of options. This methodology is virtually undisputed to be superior from a theoretical point of view. But without global application industrial electricity users will still face the competitive disadvantage caused by higher electricity prices.
Fuel-specific PSRs (Performance Standard Rates) are often considered as a possible solution. It is often claimed that a uniform PSR – the last alternative – would be unacceptable for Member States with a high proportion of coal and lignite (e.g. Germany).
PSR (Performance Standard Rate) and its consequences will be analysed in comparison with the former alternatives.

I.2 Policy objectives to evaluate allocation options

Policy objectives are used in order to evaluate current allocation rules and the alternatives mentioned above, they are derived from the requirements of the emissions trading Directive:

- Fitness for purpose, the objective function
    - Stimulation[1] to invest to reduce emissions (article 1)
    - To invest where abatement costs are lowest (article 1)
    - To avoid leakage of emissions outside the EU (recital 3)
    - Robustness, the solution should be applicable to other products as well
- Innovation & efficiency (article 1 and recital 20)
    - Stimulation of energy efficient technologies including CHP[2]
    - Stimulation of novel low carbon technologies
- Level playing field (Annex III, 5 and recital 7)
    - No undue favouring of and no discrimination between certain companies, activities or sectors; same allocation to similar installations
    - Worldwide level playing field: least possible diminution of economic development and employment (recital 5)
    - No frozen market shares (undistorted market, EC Treaty via Annex III (5))
- Polluter-pays principle (EC Treaty)

[1] When stimulation is mentioned it must be read as additional stimulation because most often lower energy costs provide already stimulation. Exceptions are for example fuel choice and clean coal.
[2] Combined Heat & Power.

II Fixed costs of electricity plants

Gross margins of electricity plants are important to judge windfall profits. They need to be considered with respect to their fixed costs. The following table shows two examples, a new CCGT (Combined Cycle Gas Turbine) plant and a new coal-fired plant[3]:

Costs above fuel	**New CCGT (Combined Cycle Gasturbine) 600 MWe**	**New coal plant 750 MWe**
	€/MWh	€/MWh
Variable Operating & Maintenance	1.50	3.33
Fixed Operating & Maintenance	2.33	3.50
Capital cost incl. ROI excl. depreciation	2.90	7.42
Fixed cost incl. ROI	**6.73**	**14.25**
Depreciation	2.85	5.23
Long-run marginal fixed costs	**9.58**	**19.48**

In a truly competitive market, prices are depressed in case of oversupply; prices on the level of long run marginal cost or higher can be obtained when the market is in tight supply. Note: these margins include the full cost for gas, including capacity and transport costs.

Rounded figures long run marginal cost:

- Gas-fired CCGT: € 10/MWh
- Coal-fired plants: € 20/MWh

Rounded figures for a competitive market with ample supply:

- Gas-fired CCGT: € 7/MWh
- Coal-fired plants: € 15/MWh

III Shortage of allowances and fuel switch

To achieve an emissions trading scheme that functions, the European Commission has created a shortage of allowances by scrutinizing National Allocation Plans (NAPs). NAPs with too high an allocation were forced to reduce the total amount of allowances below predicted emissions under a business as usual scenario. Currently, estimates of analysts of the total shortage in the EU-25 market vary between 100 Mton CO_2 and 180-200 Mton CO_2 up to 270 Mton CO_2 in the first 3-year trading period (35 or 65 up to 90 Mton/year).

This shortage of allowances cannot easily be overcome by investments to reduce emissions; this requires a lead-time of several years (4-6 years for larger projects). But electricity producers can switch from coal-fired electricity to gas-fired electricity in existing spare capacities ("fuel switch"). This mechanism is therefore a major driver for the market price of CO_2. In this way the electricity producers as a whole will become <u>net-sellers</u> of allowances <u>if</u> the other sectors are also short of allowances.

Other factors influencing the shortage of allowances – and hence the price for CO_2 – are of great importance as well, such as:

- JI/CDM credits lower the shortage in the market
- Dry weather causes less electricity from hydropower (e.g. Spain in 2005)
- Shut down of aluminium plants caused by high electricity prices lower the shortage as less electricity is needed
- The same is true when cement production is replaced by imports from outside the EU
- The latter two mechanisms lead to "leakage" (export) of emissions[4]

[3] Source: "Emissions trading and its possible impacts on investment decisions in the power sector", by Julia Renaud, 2003, IEA (International Energy Agency)

IV Regional differences in the electricity market

The sources of electricity production differ greatly from one country to the other. As an example the production in 2003 by source is indicated in the table below:

Electricity Production 2003 (rounded data)	**Lignite**	**Coal**	**Oil**	**Gas**	**Nuclear**	**Wind**	**Hydro**
Germany	**28%**	**25%**	1%	10%	**29%**	**3%**	4%
France	0%	5%	2%	3%	**79%**	0.1%	**11%**
UK	0%	**37%**	2%	**39%**	**20%**	0.3%	1.5%
Netherlands	0%	**27%**	3%	**64%**	4.5%	<0.1%	1.5%
Belgium	0%	12%	1.2%	**27%**	**58.5%**	0.1%	1.5%
Spain	**5%**	**26%**	9%	15%	**23.5%**	**4.5%**	**17%**
Italy	0%	14%	**27%**	**42%**	0%	1.2%	**16%**
Austria	2%	11%	3%	**19%**	0%	<0.5%	**64%**
Norway	0%	0%	0%	<0.5%	0%	0%	**>99.5%**
Sweden	0%	2%	3%	0.5%	**52%**	0.5%	**42%**
Finland	**9%**	**26%**	2%	**19%**	**31%**	<0.1%	**13%**
Denmark	0%	**59%**	5%	**23%**	0%	**13%**	0%

A high proportion of coal and lignite is present in Denmark and Germany. Then follow Finland, UK, Spain and the Netherlands. Netherlands leads on the use of natural gas, followed by Italy, UK, Belgium, Denmark, Finland and Austria.

Countries favoured by the possibility of hydropower are Norway, Austria, Spain, Italy, Finland and France. Nuclear could be seen as a supplement of hydropower and is extensively used in France, Belgium and Sweden with smaller but still significant shares in Finland (will grow due to the new plant under construction), Germany and UK. Netherlands and Denmark have (virtually) no hydropower and no nuclear; Denmark is leader in wind energy in relative terms.

The share of electricity produced from various sources is not the determining factor for the price of electricity; the price is set by the annual share of the marginal plants within Member States. This is illustrated below (source: Energy Focus Electricity, estimates on personal authority by Franck Schuttelaar, Gaselys, September 2005; Netherlands estimate V. Schyns):

Type of plant	Emission factor Ton CO_2/MWh	Marginal dispatch period (annual %)			
		Germany	France	UK	Netherlands
Nuclear	0	-	34%	-	-
Lignite	1.1[5] (source PWC)	15%	-	-	-
Coal	0.9	60%	57%	18%	50%
Gas	0.4	25%	-	82%	50%
Fuel oil	0.85	-	9%	-	-
Average marginal ton CO_2/MWh		**0.81**	**0.59**	**0.49**	**0.65**

[4] In the report “Climate change challenges and the search for a sustainable policy”, 21 June 2005, Vianney Schyns, it is stated that leakage is clearly in conflict with the Directive (no contribution to global climate). In recital 3 the ultimate objective of the United Nations Framework Convention on Climate Change is mentioned: to achieve stabilisation of greenhouse gas concentrations in the atmosphere at a level which prevents dangerous anthropogenic interference with the climate system. In many economic studies the leakage ranges from 15%-20%. This is interpreted as one ton of reduction yields an additional emission of 0.15-0.20 ton outside the EU. But when for example cement production is replaced by equal or less efficient import from outside the EU, the leakage is >/= 100% in this case. Leakage has therefore a zero or negative contribution to the global climate problem.

[5] Franck Schuttelaar used 0.9 ton CO_2/MWh.

V Cap & trade

V.1 Opportunity-cost caused by cap & trade

Under a cap & trade system, electricity producers have the opportunity to sell allowances if they lower production and not sell electricity. But unlike chemicals and many other commodities, electricity cannot be imported from outside the European Union. Therefore under cap & trade electricity producers must incorporate the full cost of CO_2-allowances in the price of electricity. This cost is known as the ***opportunity-cost*** because generally about 95% of the needed allowances were granted free of charge to the electricity producers.

In a first most simple example of two power plants – assuming a "higher" price differential between coal and natural gas – the effects of cap & trade are demonstrated. The opportunity-cost (in the table: E1 x C1, E1 x C2, etc. for the gas-fired plant and E2 x C1, E2 x C2, etc. for the coal-fired plant) have to be added to the fuel costs of each plant.

Cap & trade
Higher price differential
coal - gas

Full delivered fuel prices	€/GJ		€/MWh	€ cent/m3 Groningen
Coal	1,8	38%	6,5	5,1
Gas	4,7		16,9	13,4

Cheapest	More expensive

CO_2-price (EURO/ton)

SRMC = Short Run Marginal Cost

Fuel	Technology	Efficiency	ton CO_2 per MWh	Fuel cost €/MWh	5 SRMC	10 SRMC	15 SRMC	20 SRMC	25 SRMC	30 SRMC	33,9 SRMC	35 SRMC	40 SRMC	45 SRMC	50 SRMC
					C1	C2	Etc								
								Break-even for fuel switch:							
			E1	F1	SRMC = F1 + E1 x C										
Gas	CCGT average (Combined Cycle Gas Turbine)	49%	0,41	34,5	36,6	38,7	40,7	42,8	44,8	46,9	**48,5**	49,0	51,0	53,1	55,1
			E2	F2	SRMC = F2 + E2 x C										
Coal	Average (Average eficiency)	37%	0,91	17,5	22,1	26,7	31,2	35,8	40,4	45,0	**48,5**	49,5	54,1	58,7	63,2

Costs incurred by a shortage of allowances are not included in this first simplified model.

In this particular case, the short run marginal cost (SRMC) including opportunity-cost are exactly the same for both plants at an electricity price of € 48.5/MWh and a CO_2-price of € 33.9/ton. This is the break-even price for fuel switch. Electricity from this CCGT plant can replace electricity from this average efficiency coal-fired plant.

V.2 The functioning of cap & trade for electricity in detail

The functioning of cap & trade for electricity producers is further elaborated in more detailed analyses (on the next pages) of the cash flows, prices and emissions of these two plants. The purpose is to gain understanding of the present allocation rules in order to be able to compare it better with alternatives.

In the next models it is assumed that both power plants got a cap of 95% of historical emissions and that the switch will be limited to cope with this shortage only[6]. For reasons of simplicity the market demand of electricity is kept constant[7]. The cash flow and price effects are compared with assumed historical margins of € 7/MWh and € 15/MWh for the gas-fired and the coal-fired plant respectively.

To predict the rational behaviour of a fully competitive market is complex under the cap & trade regime. Therefore three cases are explored:
Case A: minimum electricity price that producers are likely to ask
Case B: straightforward marginal pricing
Case C: equilibrium cash flow pricing for coal-fired electricity (before and after fuel switch)

[6] In reality fuel switch can also lower emissions further to cope with a shortage of allowances of other sectors or the switch can be less if other sectors have a surplus of allowances.
[7] In reality market demand grows.

Case A: minimum electricity price that producers are likely to ask

Cap & trade
Higher price differential coal - gas **CASE A**

Full delivered fuel prices	€/GJ	
Coal	1,8	38%
Gas	4,7	

Cheapest More expensive
SRMC = Short Run Marginal Cost
MPCM = Market Price at Competitive Margin

Fuel	Technology	Competitive gross margins €/MWh	Efficiency	ton CO_2 per MWh	Fuel cost €/MWh	CO_2-price (EURO/ton) 0	5	10	15	20	25	30	33,9	33,9	40	45	50
							MPCM or SRMC, whatever is higher:						Before switch	After switch			
						MPCM	MPCM	MPCM	MPCM	SRMC	SRMC	SRMC	SRMC	SRMC	SRMC	SRMC	SRMC
Gas	CCGT average	7,0	49%	0,41	34,5	41,5	41,6	41,7	41,8	42,8	44,8	46,9	48,5	48,5	51,0	53,1	55,1
Coal	Average	15,0	37%	0,91	17,5	32,5	32,7	33,0	33,2	35,8	40,4	45,0	48,5	48,5	54,1	58,7	63,2

		0	5	10	15	20	25	30	33,9	33,9	40	45	50
Market price at high demand (€/MWh)	50%	41,5	41,6	41,7	41,8	42,8	44,8	46,9	48,5	48,5	54,1	58,7	63,2
Market price at low demand (€/MWh)	50%	32,5	32,7	33,0	33,2	35,8	40,4	45,0	48,5	48,5	54,1	58,7	63,2
Gas-fired power plant	MWe:	100	100	100	100	100	100	100	100	122	122	122	122
Emission (kton CO2/annum) assume 8000 hrs/year		330	330	330	330	330	330	330	330	403	403	403	403
Assume cap of historical emission (kton CO2/annum)	95%	313	313	313	313	313	313	313	313	313	313	313	313
Shortage of allowances (kton CO2/year)		16	16	16	16	16	16	16	16	90	90	90	90
Cost of allowances (EURO mln/annum)		0	0,1	0,2	0,2	0,3	0,4	0,5	0,6	3,0	3,6	4,1	4,5
Assume historical margin (EURO/MWh)		7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0
Historical margin without switch (EURO mln/annum)		5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6
Margin after cost allowances (EURO/MWh)		7,0	7,0	7,0	7,0	7,8	9,8	11,7	13,3	10,8	15,9	20,0	24,1
Margin after cost allowances (EURO mln/annum)		5,6	5,6	5,6	5,6	6,3	7,8	9,4	10,6	10,6	16	19,6	23,6
Windfall margin (EURO/MWh)		0,0	0,0	0,0	0,0	0,8	2,8	4,7	6,3	3,8	8,9	13,0	17,1
Coal-fired power plant	MWe:	200	200	200	200	200	200	200	200	178	178	178	178
Emission (kton CO2/annum) assume 8000 hrs/year		1463	1463	1463	1463	1463	1463	1463	1463	1300	1300	1300	1300
Assume cap of historical emission (kton CO2/annum)	95%	1390	1390	1390	1390	1390	1390	1390	1390	1390	1390	1390	1390
Shortage of allowances (kton CO2/year)		73	73	73	73	73	73	73	73	-90	-90	-90	-90
Cost of allowances (EURO mln/annum)		0	0,4	0,7	1,1	1,5	1,8	2,2	2,5	-3,0	-3,6	-4,1	-4,5
Assume historical margins depending on market place		Gross margin gas-fired:						7,0	Gross margin coal-fired when marginal				15,0
Indication Netherlands: 50% 50%	Gas / coal	Gross margin coal-fired when gas-fired is marginal:											24,0
Average historical margin coal-fired electricity (EURO/MWh)		19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5
Historical margin without switch (EURO mln/annum)		31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2
Margin after cost allowances (EURO/MWh)		19,5	19,4	19,4	19,3	20,9	23,9	27,0	29,4	33,1	39,1	44,0	48,9
Margin after cost allowances (EURO mln/annum)		31,2	31,1	31,0	30,9	33,4	38,3	43,3	47,1	47,1	55,6	62,6	69,5
Windfall margin (EURO/MWh)		0,0	-0,1	-0,1	-0,2	1,4	4,4	7,5	9,9	13,6	19,6	24,5	29,4
Totals for the two power plants									Before switch	After switch			
Margin after cost allowances (EURO mln/annum)		36,8	36,7	36,6	36,5	39,6	46,2	52,7	57,7	57,7	71,2	82,1	93,1
Historical margin without switch (EURO mln/annum)		36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8
Total fuel cost (EURO mln/annum)		55,6	55,6	55,6	55,6	55,6	55,6	55,6	55,6	58,7	58,7	58,7	58,7
Cost of allowances (EURO mln/annum)		0	0,4	0,9	1,3	1,8	2,2	2,7	3,0	0,0	0,0	0,0	0,0
Windfall profits: margin - historical margin (EURO mln/annum)		0	-0,1	-0,2	-0,3	2,8	9,3	15,8	20,9	20,9	34,3	45,3	56,3
Windfall profits (%)						8%	25%	43%	57%	57%	93%	123%	153%
Windfall profit (€/MWh)		0	-0,04	-0,1	-0,1	1,2	3,9	6,6	8,7	8,7	14,3	18,9	23,5
Average price: margin + cost of fuel + allowances (€/MWh)		38,5	38,7	38,8	39,0	40,5	43,3	46,2	48,5	48,5	54,1	58,7	63,2
Higher price of electricity by emissions trading (€/MWh)		0	0,1	0,3	0,4	1,9	4,8	7,7	10,0	10,0	15,6	20,1	24,7
Higher fuel cost by emissions trading (€/MWh)		0	0	0	0	0	0	0	0,0	1,3	1,3	1,3	1,3
Higher cost of the allowances by Emissions trading (€/MWh)		0	0,2	0,4	0,6	0,7	0,9	1,1	1,3	0,0	0,0	0,0	0,0
Market demand (MWe)		300	300	300	300	300	300	300	300	300	300	300	300
Total cap (kton CO2/annum)		1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703
Total emission (kton CO2/annum)		1793	1793	1793	1793	1793	1793	1793	1793	1703	1703	1703	1703
Total shortage (kton CO2/annum)		90	90	90	90	90	90	90	90	0	0	0	0

Observations:

- The break-even prices for fuel switch are € 33.9/ton CO_2 and € 48.5/MWh.
- Before fuel switch the shortage of allowances is 90 kton CO_2/year (see bottom line).
- This shortage is overcome by increasing production of the gas-fired plant (from 100 to 122 MWe) and lowering production of the coal-fired plant (from 200 to 178 MWe). This is possible by the lower emission per MWh of the gas-fired power plant.
- After the switch the gas-fired plant needs to buy 90 kton/year allowances (this was before the switch 16 kton/year). The margin per year after cost of allowances remains the same as before fuel switch because the higher amount of electricity produced compensates exactly for the higher cost of buying allowances at the fuel switch price (table: margin € 10.6 mln/year).
- After the switch the coal-fired plant will sell 90 kton/year allowances (before the switch this plant needed to buy 73 kton/year). The margin per year after cost of allowances remains the same as before fuel switch because the lower amount of electricity produced is compensated exactly by the revenues of selling allowances at the fuel switch price (table: margin € 47.1 mln/year).
- At the switch price the total margin has increased from an assumed historical margin of € 36.8 mln/year to € 57.7 mln/year. The additional profit caused by the system of cap & trade is referred to as **windfall profit:** in this example € 20.9 mln/year or **57%**.

- In the real market CO_2-prices may further increase when more fuel switch is needed – this will be explained hereafter – and therefore windfall profits may further increase.

Discussion:

- This first mechanism seems to be the most elegant because cash flows of both plants are the same before and after fuel switch. It is the mechanism that assumes the most competitive behaviour, which may happen for cases in which the shortage of allowances is rather small, e.g. 5% or 10%.
- If on the other hand – and that is case B – the short run marginal cost would fully include the cost of allowances of the marginal (last) MWh (because of the shortage, in this case 5%), there would be in immediate windfall profit over all remaining MWh (which have no shortage). The gross margin on the marginal MWh would then also be € 7/MWh, and thus creating a higher margin for the MWh not affected by the shortage.
- Therefore in case A the cost for the need to buy 5% allowances is spread over all MWh produced. The gas-fired plant needs then a small price increase to achieve the historical margin of € 7/MWh over the entire production.
- This <u>minimum</u> approach of case A has a significant consequence: opportunity-costs are always considered and as soon as opportunity-costs are higher than the historical margin the former will prevail. After that the gross margin increases as the CO_2-price further rises.

- Without emissions trading coal-fired power plants have already a “secondary windfall profit” when gas is sufficiently more expensive than coal (as in this example) and gas-fired plants are marginal (50% of annual time in this example). They profit from the higher MPCM for gas (market price at competitive margin). This is taken into account when calculating the windfall profit caused by cap & trade emissions trading.
- Therefore, by the need to buy 5% allowances, the gross margin of the coal-fired plant, when gas-fired plans are marginal, decreases very slowly until opportunity-cost are higher than the “normal” gross margin (at about € 20/ton CO_2). As mentioned above, the gross margin of gas-fired plants is not affected when this plant is marginal; the electricity price increases slightly to take the cost of the shortage of allowances into account.
- The higher price caused by cap & trade emissions trading at the break-even price for fuel switch **(€ 10.0/MWh** in this example) is the same before and after the switch.
- If both plants are owned by one operator, the real cost of fuel switch are only the increased cost of gas if compared to coal, corrected for the difference in efficiency. The increased fuel costs are in this example € 3.1 mln/year or **€ 1.3/MWh** (see box in the table), **only 13%** of the higher price caused by cap & trade emissions trading.
- Above a price of about € 20/ton CO_2 competition is out of the market. The gross margins increase automatically as the CO_2-price increases. It will be explained later precisely why producers cannot produce and sell below opportunity-costs.

Case B: straightforward marginal pricing

In case B a more rigorous approach is chosen: the cost of allowances of the marginal MWh is charged fully in the electricity price above the normal margin of € 7/MWh and € 15/MWh for gas-fired and coal-fired power plants respectively.

This leads to the following picture:

Case B: straightforward marginal pricing

Cap & trade Higher price differential coal - gas — **CASE B**

Full delivered fuel prices	€/GJ	
Coal	1,8	38%
Gas	4,7	

Cheapest | More expensive

SRMC = Short Run Marginal Cost

MPCM = Market Price at Competitive Margin

Fuel	Technology	Competitive gross margins €/MWh	Efficiency	ton CO_2 per MWh	Fuel cost €/MWh
Gas	CCGT average	7,0	49%	0,41	34,5
Coal	Average	15,0	37%	0,91	17,5

CO_2-price (EURO/ton)		0	5	10	15	17,9	17,9	20	25	30	35	40	45	50
			MPCM or SRMC,			Before switch	After switch							
		MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM
Gas CCGT average		41,5	43,6	45,7	47,7	48,9	48,9	49,8	51,8	53,9	56,0	58,0	60,1	62,1
Coal Average		32,5	37,1	41,7	46,2	48,9	48,9	50,8	55,4	60,0	64,5	69,1	73,7	78,2
Market price at high demand (€/MWh)	50%	41,5	43,6	45,7	47,7	48,9	48,9	50,8	55,4	60,0	64,5	69,1	73,7	78,2
Market price at low demand (€/MWh)	50%	32,5	37,1	41,7	46,2	48,9	48,9	50,8	55,4	60,0	64,5	69,1	73,7	78,2
Gas-fired power plant	MWe:	100	100	100	100	100	122	122	122	122	122	122	122	122
Emission (kton CO2/annum) assume 8000 hrs/year		330	330	330	330	330	403	403	403	403	403	403	403	403
Assume cap of historical emission (kton CO2/annum)	95%	313	313	313	313	313	313	313	313	313	313	313	313	313
Shortage of allowances (kton CO2/year)		16	16	16	16	16	90	90	90	90	90	90	90	90
Cost of allowances (EURO mln/annum)		0	0,1	0,2	0,2	0,3	1,6	1,8	2,3	2,7	3,2	3,6	4,1	4,5
Assume historical margin (EURO/MWh)		7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0
Historical margin without switch (EURO mln/annum)		5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6
Margin after cost allowances (EURO/MWh)		7,0	9,0	10,9	12,9	14,0	12,7	14,4	18,5	22,7	26,8	30,9	35,0	39,1
Margin after cost allowances (EURO mln/annum)		5,6	7,2	8,7	10,3	11,2	12,5	14	18,1	22,2	26,2	30,2	34,2	38,3
Windfall margin (EURO/MWh)		0,0	2,0	3,9	5,9	7,0	5,7	7,4	11,5	15,7	19,8	23,9	28,0	32,1
Coal-fired power plant	MWe:	200	200	200	200	200	178	178	178	178	178	178	178	178
Emission (kton CO2/annum) assume 8000 hrs/year		1463	1463	1463	1463	1463	1300	1300	1300	1300	1300	1300	1300	1300
Assume cap of historical emission (kton CO2/annum)	95%	1390	1390	1390	1390	1390	1390	1390	1390	1390	1390	1390	1390	1390
Shortage of allowances (kton CO2/year)		73	73	73	73	73	-90	-90	-90	-90	-90	-90	-90	-90
Cost of allowances (EURO mln/annum)		0	0,4	0,7	1,1	1,3	-1,6	-1,8	-2,3	-2,7	-3,2	-3,6	-4,1	-4,5
Assume historical margins depending on market place		Gross margin gas-fired:				7,0		Gross margin coal-fired when marginal:						15,0
Indication Netherlands: 50% 50%	Gas / coal	Gross margin coal-fired when gas-fired is marginal:												24,0
Average historical margin coal-fired electricity (EURO/MWh)		19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5
Historical margin without switch (EURO mln/annum)		31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2
Margin after cost allowances (EURO/MWh)		19,5	22,6	25,7	28,8	30,6	32,6	34,6	39,4	44,3	49,2	54,1	59,0	63,9
Margin after cost allowances (EURO mln/annum)		31,2	36,2	41,1	46,0	48,9	46,3	49,1	56,1	63,0	70,0	76,9	83,9	90,8
Windfall margin (EURO/MWh)		0,0	3,1	6,2	9,3	11,1	13,0	15,1	19,9	24,8	29,7	34,6	39,5	44,4
Totals for the two power plants						Before switch	After switch							
Margin after cost allowances (EURO mln/annum)		36,8	43,3	49,8	56,3	60,2	58,7	63,3	74,2	85,2	96,2	107,2	118,1	129,1
Historical margin without switch (EURO mln/annum)		36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8
Total fuel cost (EURO mln/annum)		55,6	55,6	55,6	55,6	55,6	58,7	58,7	58,7	58,7	58,7	58,7	58,7	58,7
Cost of allowances (EURO mln/annum)		0	0,4	0,9	1,3	1,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Windfall profits: margin - historical margin (EURO mln/annum)		0	6,5	13,0	19,5	23,4	21,9	26,4	37,4	48,4	59,4	70,3	81,3	92,3
Windfall profits (%)			18%	35%	53%	63%	60%	72%	102%	131%	161%	191%	221%	251%
Windfall profit (€/MWh)		0	2,71	5,4	8,1	9,7	9,1	11,0	15,6	20,2	24,7	29,3	33,9	38,5
Average price: margin + cost of fuel + allowances (€/MWh)		38,5	41,4	44,3	47,2	48,9	48,9	50,8	55,4	60,0	64,5	69,1	73,7	78,2
Higher price of electricity by emissions trading (€/MWh)		0	2,9	5,8	8,7	10,4	10,4	12,3	16,9	21,4	26,0	30,6	35,1	39,7
Higher fuel cost by emissions trading (€/MWh)		0	0	0	0	0,0	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1,3
Higher cost of the allowances by Emissions trading (€/MWh)		0	0,2	0,4	0,6	0,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Market demand (MWe)		300	300	300	300	300	300	300	300	300	300	300	300	300
Total cap (kton CO2/annum)		1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703
Total emission (kton CO2/annum)		1793	1793	1793	1793	1793	1703	1703	1703	1703	1703	1703	1703	1703
Total shortage (kton CO2/annum)		90	90	90	90	90	0	0	0	0	0	0	0	0

Observations:

- Taking the marginal cost of allowances fully into account means that there are no opportunity-costs but only hard costs before fuel switch (there is a need to buy).
- Therefore windfall profits start immediately at low CO_2-prices: the higher cost for the small shortage of allowances causes a higher electricity price and hence a windfall profit for the MWh that have no shortage of allowances.
- After the fuel switch the marginal costs of allowances are hard costs for the gas-fired plant (need to buy) and opportunity-costs for the coal-fired plant (this plant will sell).
- At break-even electricity price, the marginal electricity the coal-fired and the gas-fired plants have the same historical gross margins: € 7/MWh and € 15/MWh respectively.
- Therefore, the break-even CO_2-price has decreased from € 33.9/ton to € 17.9/ton. The gas-fired plant needs a lower gross margin than the coal-fired plant.
- At fuel switch the break-even electricity price and **windfall profits** are slightly higher than in case A.
- Marginal pricing means that after fuel switch the average margin/MWh of the gas-fired plant decreases, but this effect is more than compensated by the higher total margin in € mln/year because of the higher production.
- Marginal pricing means that after fuel switch the average margin/MWh of the coal-fired plant increases, but this leads to a lower total margin in € mln/year because of the lower production.

Therefore in case B the coal-fired power plant will not be willing to lower production and sell allowances at this break-even price price. A higher price is needed, and this new break-even price is calculated in **case C.**

Case C: equilibrium cash flow pricing for coal-fired electricity

Cap & trade
Higher price differential coal - gas — **CASE C**

Full delivered fuel prices	€/GJ	
Coal	1,8	38%
Gas	4,7	

Cheapest / More expensive

MPCM = Market Price at Competitive Margin

CO₂-price (EURO/ton) — €/MWh: 1,9 Extra margin

Fuel	Technology	Competitive gross margins €/MWh	Efficiency	ton CO_2 per MWh	Fuel cost €/MWh	0	5	10	15	17,9	17,9	17,9	25	30	35	40	45	50
										Before switch	After switch							
						MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM
Gas	CCGT average	7,0	49%	0,41	34,5	41,5	43,6	45,7	47,7	48,9	48,9	50,8	51,8	53,9	56,0	58,0	60,1	62,1
Coal	Average	15,0	37%	0,91	17,5	32,5	37,1	41,7	46,2	48,9	48,9	50,8	57,3	61,8	66,4	71,0	75,6	80,1

		0	5	10	15	17,9	17,9	17,9	25	30	35	40	45	50
Market price at high demand (€/MWh)	50%	41,5	43,6	45,7	47,7	48,9	48,9	50,8	57,3	61,8	66,4	71,0	75,6	80,1
Market price at low demand (€/MWh)	50%	32,5	37,1	41,7	46,2	48,9	48,9	50,8	57,3	61,8	66,4	71,0	75,6	80,1
Gas-fired power plant MWe:		100	100	100	100	100	122	122	122	122	122	122	122	122
Emission (kton CO2/annum) assume 8000 hrs/year		330	330	330	330	330	403	403	403	403	403	403	403	403
Assume cap of historical emission (kton CO2/annum)	95%	313	313	313	313	313	313	313	313	313	313	313	313	313
Shortage of allowances (kton CO2/year)		16	16	16	16	16	90	90	90	90	90	90	90	90
Cost of allowances (EURO mln/annum)		0	0,1	0,2	0,2	0,3	1,6	1,6	2,3	2,7	3,2	3,6	4,1	4,5
Assume historical margin (EURO/MWh)		7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0
Historical margin without switch (EURO mln/annum)		5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6
Margin after cost allowances (EURO/MWh)		7,0	9,0	10,9	12,9	14,0	12,7	14,6	20,4	24,5	28,7	32,8	36,9	41,0
Margin after cost allowances (EURO mln/annum)		5,6	7,2	8,7	10,3	11,2	12,5	14,3	20,0	24,0	28,0	32,1	36,1	40,1
Windfall margin (EURO/MWh)		0,0	2,0	3,9	5,9	7,0	5,7	7,6	13,4	17,5	21,7	25,8	29,9	34,0
Coal-fired power plant MWe:		200	200	200	200	200	178	178	178	178	178	178	178	178
Emission (kton CO2/annum) assume 8000 hrs/year		1463	1463	1463	1463	1463	1300	1300	1300	1300	1300	1300	1300	1300
Assume cap of historical emission (kton CO2/annum)	95%	1390	1390	1390	1390	1390	1390	1390	1390	1390	1390	1390	1390	1390
Shortage of allowances (kton CO2/year)		73	73	73	73	73	-90	-90	-90	-90	-90	-90	-90	-90
Cost of allowances (EURO mln/annum)		0	0,4	0,7	1,1	1,3	-1,6	-1,6	-2,3	-2,7	-3,2	-3,6	-4,1	-4,5
Assume historical margins depending on market place		Gross margin gas-fired:				7,0		Gross margin coal-fired when marginal:						15,0
Indication Netherlands: 50% 50%	Gas / coal	Gross margin coal-fired when gas-fired is marginal:												24,0
Average historical margin coal-fired electricity (EURO/MWh)		19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5
Historical margin without switch (EURO mln/annum)		31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2
Margin after cost allowances (EURO/MWh)		19,5	22,6	25,7	28,8	30,6	32,6	34,4	41,3	46,2	51,1	56,0	60,9	65,8
Margin after cost allowances (EURO mln/annum)		31,2	36,2	41,1	46,0	48,9	46,3	48,9	58,8	65,7	72,7	79,6	86,6	93,5
Windfall margin (EURO/MWh)		0,0	3,1	6,2	9,3	11,1	13,0	14,9	21,8	26,7	31,6	36,5	41,4	46,3
Totals for the two power plants						Before switch	After switch							
Margin after cost allowances (EURO mln/annum)		36,8	43,3	49,8	56,3	60,2	58,7	63,3	78,7	89,7	100,7	111,7	122,6	133,6
Historical margin without switch (EURO mln/annum)		36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8
Total fuel cost (EURO mln/annum)		55,6	55,6	55,6	55,6	55,6	58,7	58,7	58,7	58,7	58,7	58,7	58,7	58,7
Cost of allowances (EURO mln/annum)		0	0,4	0,9	1,3	1,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Windfall profits: margin - historical margin (EURO mln/annum)		0	6,5	13,0	19,5	23,4	21,9	26,4	41,9	52,9	63,9	74,9	85,8	96,8
Windfall profits (%)			18%	35%	53%	63%	60%	72%	114%	144%	174%	203%	233%	263%
Windfall profit (€/MWh)		0	2,71	5,4	8,1	9,7	9,1	11,0	17,5	22,0	26,6	31,2	35,8	40,3
Average price: margin + cost of fuel + allowances (€/MWh)		38,5	41,4	44,3	47,2	48,9	48,9	50,8	57,3	61,8	66,4	71,0	75,6	80,1
Higher price of electricity by emissions trading (€/MWh)		0	2,9	5,8	8,7	10,4	10,4	12,3	18,7	23,3	27,9	32,5	37,0	41,6
Higher fuel cost by emissions trading (€/MWh)		0	0	0	0	0,0	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1,3
Higher cost of the allowances by Emissions trading (€/MWh)		0	0,2	0,4	0,6	0,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Market demand (MWe)		300	300	300	300	300	300	300	300	300	300	300	300	300
Total cap (kton CO2/annum)		1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703
Total emission (kton CO2/annum)		1793	1793	1793	1793	1793	1703	1703	1703	1703	1703	1703	1703	1703
Total shortage (kton CO2/annum)		90	90	90	90	90	0	0	0	0	0	0	0	0

Observations:

- At a higher price of € 1.9/MWh the total gross margin in € mln/year of the coal-fired plant after fuel switch is equal to the total gross margin before fuel switch.
- Windfall profits increase further if compared to case B from 60% to 72%.

Conclusions cap & trade for electricity

- **Case A:** The least cost approach leads to a break-even CO_2-price of € 33.9/ton and a break-even electricity price of € 48.5/MWh in this example. The windfall profits are absent below € 20/ton and 57% at the fuel switch level.
- **Case B:** Marginal pricing leads to a much lower break-even CO_2-price of € 17.9/ton but a slightly higher break-even electricity price of € 48.9/MWh in this example. The windfall profits start immediately at low CO_2-prices and are 60% after fuel switch. But case B is not realistic as a coal-fired plant will not be willing to accept a lower total margin after fuel switch. Case C addresses this point.
- **Case C:** Equilibrium cash flow pricing for the coal-fired power plant leads in comparison to case B to the same break-even CO_2-price of € 17.9/ton and a slightly higher break-even electricity price of € 50.8/MWh in this example. The windfall profits start immediately at low CO_2-prices and are 72% after fuel switch.
- It appears that the break-even prices for electricity increase slightly from cases A to B to C, but they are in the same order of magnitude.
- There is ambiguity for the break-even price of CO_2, this price differs greatly between case A (high) and cases B and C (low). This is important because the mechanism of fuel switch is a main price driver for the CO_2-market as a whole. This phenomenon deserves therefore further study.
- Windfall profits at the level of fuel switch are about the same for cases A and B and higher for case C. In case A windfall profits are the lowest, before and after fuel switch: below € 20/ton there are no windfall profits.

It is too early to finally conclude what has been happening until now in the market. Only cases A and C are realistic options, but in the end it is a management decision. Other considerations than those used in the models may come into play. Anyhow, in 2005 there was hardly any fuel switch and in a large part of the second half of 2005 CO_2-prices were lower than they should have been to effect a fuel switch.

As there is in most Member States a shortage of allowances for electricity producers, case C is the normal rational model to be expected. The consequence is that windfall profits are in the order of at least € 11-12/MWh (or higher, with lignite) at CO_2-prices of € 20-22/ton, the market price of the last quarter of 2005.

Please note that in this model the shortage of emissions cannot be below 55%. Then the coal-fired plant producers no electricity anymore and the gas-fired plant produces 300 MWe (if this plant would have this capacity).

In this example it is further assumed that coal-fired power plants are always needed and that gas-fired plants are needed when demand is high and that there is not enough gas-fired capacity to replace coal-fired power plants completely from the market.

These assumptions are reality in any European regional market, coal-fired and lignite-fired power plants are always needed in the foreseeable future. This means that above the natural equilibrium price (€ 33.9/ton in the example) efficient gas-fired power plants are the cheapest plants and that the electricity price is always (during low and high demand) set by the coal-fired plant. The merit order is changed.

Therefore in the real market with many plants, electricity prices during high and low (night and weekend) demand will tend to come to the same level (while now night and weekend prices are much lower). In this simplified model of only two power plants day and night prices are then equal.

V.3 Wide range of fuel switches

From now on case A will be used as basis for the analysis, a conservative approach. In the real electricity market a great variety of power plants supply the market. This will then lead to a wide range of fuel-switch possibilities. How far fuel switch needs to go depends on the shortage in the market of allowances. A range of switches is illustrated in the following colourful table, now with a higher price for natural gas (not all switches, the switches between gas-fired plants with 40% and 35% efficiency in this model are not shown):

Cap & trade
Higher differential coal - gas

Full delivered fuel prices	€/GJ	
Coal	1,8	38%
Gas	4,7	

1	2	3	4	5	6	7	8	9	10
									white
Cheapest								**Most expensive**	

SRMC = Short Run Marginal Cost

Fuel	Technology	Efficiency	ton CO_2 per MWh	Fuel cost €/MWh Switch:	CO_2-price (EURO/ton) 10 SRMC	19,2 SRMC 1	21,6 SRMC 2+ 3	24,2 SRMC 4	25,6 SRMC 5	25,8 SRMC 6	28,6 SRMC 7	28,9 SRMC 8	32,1 SRMC 9	33,9 SRMC 10
Gas	CCGT newest	54%	0,37	31,3	35,1	38,5	39,4	40,4	40,9	41,0	42,0	42,1	43,3	44,0
	CCGT modern	52%	0,39	32,5	36,4	40,0	40,9	42,0	42,5	42,6	43,6	43,8	45,0	45,7
	CCGT average	49%	0,41	34,5	38,7	42,4	43,4	44,5	45,1	45,2	46,3	46,4	47,7	48,5
	Conventional	40%	0,50	42,3	47,3	52,0	53,2	54,5	55,2	55,4	56,7	56,9	58,5	59,4
	Open loop GT	35%	0,58	48,3	54,1	59,4	60,8	62,3	63,1	63,3	64,8	65,0	66,8	67,9
Coal	Newest	43%	0,79	15,1	22,9	30,2	32,1	34,1	35,2	35,4	37,5	37,8	40,3	41,7
	Modern	40%	0,85	16,2	24,7	32,5	34,5	36,7	37,8	38,1	40,4	40,6	43,3	44,9
	Average	37%	0,91	17,5	26,7	35,1	37,3	39,7	40,9	41,2	43,6	43,9	46,8	48,5
	Old	35%	0,97	18,5	28,2	37,1	39,4	42,0	43,2	43,5	46,1	46,4	49,5	51,3
Lignite	Average		1,00	19,2	29,3	38,5	40,9	43,6	44,9	45,2	47,9	48,2	51,4	53,2

Fuel	Technology	Efficiency	ton CO_2 per MWh	Fuel cost €/MWh Switch:	CO_2-price (EURO/ton) 35,7 SRMC 11	39,4 SRMC 12	42,3 SRMC 13	43,8 SRMC 14	46,2 SRMC 15	51,5 SRMC 16	51,9 SRMC 17	60,5 SRMC 18	76,5 SRMC 19+20	96,5 SRMC 21
Gas	CCGT newest	54%	0,37	31,3	44,7	46,1	47,1	47,7	48,6	50,6	50,8	54,0	60,0	67,4
	CCGT modern	52%	0,39	32,5	46,4	47,8	48,9	49,6	50,5	52,5	52,7	56,0	62,3	70,0
	CCGT average	49%	0,41	34,5	49,2	50,8	51,9	52,6	53,6	55,8	55,9	59,5	66,1	74,3
	Conventional	40%	0,50	42,3	60,3	62,2	63,6	64,4	65,6	68,3	68,5	72,8	80,9	91,0
	Open loop GT	35%	0,58	48,3	68,9	71,1	72,7	73,6	75,0	78,1	78,3	83,3	92,5	104,0
Coal	Newest	43%	0,79	15,1	43,2	46,1	48,3	49,6	51,4	55,6	55,9	62,7	75,3	91,0
	Modern	40%	0,85	16,2	46,4	49,5	51,9	53,3	55,3	59,8	60,1	67,4	80,9	97,9
	Average	37%	0,91	17,5	50,2	53,5	56,2	57,6	59,8	64,6	65,0	72,8	87,5	105,8
	Old	35%	0,97	18,5	53,0	56,6	59,4	60,9	63,2	68,3	68,7	77,0	92,5	111,9
Lignite	Average		1,00	19,2	55,1	58,8	61,7	63,2	65,6	70,9	71,4	80,0	96,1	116,2

A high efficiency CCGT (54% efficiency) power plant is without emissions trading on the 6th rank in the merit order based on short run marginal cost; with emissions trading at this price differential between coal and gas this CCGT will be 1st rank at € 39.4/ton CO_2.

At a greater the shortage in the market more fuel switch at higher CO_2-prices will be required. In the 1st trading period switches 8-10 are often mentioned as most important.

Constraints are for example the spare capacity of existing gas-fired plants and the electricity transport capacities within regions and between regions. A high efficiency gas-fired power plant in for example the Netherlands or Germany cannot substitute a low efficiency lignite plant in for example Greece. Transport constraints will therefore cause upward pressure on the CO_2-price.

In the remainder of this paper a more limited number of power plants will be used, for reasons of simplicity, to analyse the effects of emissions trading.

V.4 Cap & trade at a "normal" price differential between coal & gas

In this simplified example – assuming a "normal" price differential between coal and gas – the effects of cap & trade are analysed. A shortage of allowances of let's say 5% as an approximation of the current EU average – is not taken into account in order to keep the model better understandable. The least cost approach of case A, with the lowest windfall profits, is chosen to determine windfall profits as a basis for comparison with alternative options.

Cap & trade "Normal" price differential coal - gas

Full delivered fuel prices	€/GJ	
Coal	1,8	45%
Gas	4,0	

Merit order: 1 2 3 4 5 — Cheapest … Most expensive

SRMC = Short Run Marginal Cost

Fuel	Technology	Efficiency	ton CO_2 per MWh	Fuel cost €/MWh	CO_2-price (EURO/ton): 5	7,5	10	15	19,6	23,6	25	27,5	30,4	37,5	40	45,1	58,0
					SRMC	SRMC	SRMC	SRMC	SRMC	SRMC	SRMC	SRMC	SRMC	SRMC	SRMC	SRMC	SRMC
								Switch:	I	II			III			IV	V
Gas	**CCGT average**	**49%**	**0,41**	29,4	31,4	32,5	33,5	35,6	**37,5**	**39,1**	39,7	40,7	**41,9**	44,8	45,9	48,0	53,3
	Conventional	40%	**0,50**	36,0	38,5	39,8	41,0	43,6	45,9	47,9	48,6	49,9	51,3	54,9	56,2	**58,8**	**65,3**
	OCGT	35%	**0,58**	41,1						54,8							
Coal	Modern	40%	**0,85**	16,2	20,4	22,5	24,7	28,9	32,8	36,2	37,4	39,5	**41,9**	47,9	50,0	54,4	**65,3**
	Average	**37%**	**0,91**	17,5	22,1	24,4	26,7	31,2	35,4	**39,1**	40,4	42,7	45,3	51,8	54,1	**58,8**	**70,6**
	Old	35%	**0,97**	18,5	23,3	25,8	28,2	33,0	**37,5**	41,4	42,7	45,1	47,9	54,8	57,2	62,1	74,6

Fuel	Technology	Efficiency	Opportunity-cost in €/MWh (SRMC - fuel cost):												
Gas	**CCGT average**	**49%**	2,1	3,1	4,1	6,2	**8,1**	**9,7**	10,3	11,3	**12,5**	15,5	16,5	18,6	23,9
	Conventional	40%	2,5	3,8	5,0	7,6	9,9	11,9	12,6	13,9	15,3	18,9	20,2	**22,8**	**29,3**
Coal	Modern	40%	4,2	6,3	8,5	12,7	16,6	20,0	21,2	23,3	**25,7**	31,7	33,8	38,2	**49,1**
	Average	**37%**	4,6	6,9	9,1	13,7	17,9	**21,6**	22,9	25,2	27,8	34,3	36,6	**41,3**	**53,1**
	Old	35%	4,8	7,3	9,7	14,5	**19,0**	22,9	24,2	26,6	29,4	36,3	38,7	43,6	56,1

The model shows five switch prices: at the first switch at € 19.6/ton CO_2 the average CCGT can substitute older less efficient coal plants and at the last switch at € 58.0/ton CO_2 a conventional gas boiler can substitute a modern coal plant.

In a competitive market opportunity-costs below assumed gross margins of € 7/MWh for gas-fired plants and € 15/MWh for coal-fired plants are taken into account for 100%, but the influence on the gross margin is still 0% in this approach (case A). Gross margins cannot be below opportunity-cost, this is explained in section V.8 below. Therefore at higher opportunity-cost than the historical gross margins without emissions trading, the gross margins are pushed up, see in the following table:

Fuel	Technology	Efficiency		Fuel + CO2 cost + margin	CO_2-price (EURO/ton): 5	7,5	10	15	19,6	23,6	25	27,5	30,4	37,5	40	45,1	58,0
Cap & trade								Switch:	I	II			III			IV	V
	Competitive gross margins		€/MWh	€/MWh	Gross margin: either € 7 or 15/MWh or opportunity-cost, whatever is higher €/MWh												
Gas	**CCGT average**	**49%**	**7,0**	36,4	7,0	7,0	7,0	7,0	**8,1**	**9,7**	**10,3**	**11,3**	**12,5**	**15,5**	**16,5**	**18,6**	**23,9**
	Conventional	40%	**7,0**	43,0	7,0	7,0	7,0	**7,6**	**9,9**	**11,9**	**12,6**	**13,9**	**15,3**	**18,9**	**20,2**	**22,8**	**29,3**
Coal	Modern	40%	**15,0**	31,2	15,0	15,0	15,0	15,0	**16,6**	**20,0**	**21,2**	**23,3**	**25,7**	**31,7**	**33,8**	**38,2**	**49,1**
	Average	**37%**	**15,0**	32,5	15,0	15,0	15,0	15,0	**17,9**	**21,6**	**22,9**	**25,2**	**27,8**	**34,3**	**36,6**	**41,3**	**53,1**
	Old	35%	**15,0**	33,5	15,0	15,0	15,0	15,0	**19,0**	**22,9**	**24,2**	**26,6**	**29,4**	**36,3**	**38,7**	**43,6**	**56,1**

Fuel	Technology	Efficiency		Fuel + gross margin	CO_2-price (EURO/ton): 5	7,5	10	15	19,6	23,6	25	27,5	30,4	37,5	40	45,1	58,0
Cap & trade								Switch:	I	II			III			IV	V
	Competitive gross margins		€/MWh	€/MWh	Market price: with gross margin € 7 or 15/MWh or opportunity-cost, whatever is higher €/MWh												
Gas	**CCGT average**	**49%**	**7,0**	36,4	36,4	36,4	36,4	36,4	**37,5**	**39,1**	**39,7**	**40,7**	**41,9**	**44,8**	**45,9**	**48,0**	**53,3**
	Conventional	40%	**7,0**	43,0	43,0	43,0	43,0	**43,6**	**45,9**	**47,9**	**48,6**	**49,9**	**51,3**	**54,9**	**56,2**	**58,8**	**65,3**
Coal	Modern	40%	**15,0**	31,2	31,2	31,2	31,2	31,2	**32,8**	**36,2**	**37,4**	**39,5**	**41,9**	**47,9**	**50,0**	**54,4**	**65,3**
	Average	**37%**	**15,0**	32,5	32,5	32,5	32,5	32,5	**35,4**	**39,1**	**40,4**	**42,7**	**45,3**	**51,8**	**54,1**	**58,8**	**70,6**
	Old	35%	**15,0**	33,5	33,5	33,5	33,5	33,5	**37,5**	**41,4**	**42,7**	**45,1**	**47,9**	**54,8**	**57,2**	**62,1**	**74,6**

From this table it can be concluded that margins start to rise as from about € 15/ton and that windfall profits then emerge.

The minimum[8] windfall profits are illustrated in the next table:

Fuel	Technology	Efficiency	Competitive gross margins €/MWh	Fuel + gross margin €/MWh	5	7,5	10	15	19,6	23,6	25,0	27,5	30,4	37,5	40,0	45,1	58,0
Cap & trade					CO₂-price (EURO/ton)			Switch:	I	II			III			IV	V
					Cap & trade windfall profits: margin above competitive margins €/MWh												
Gas	**CCGT average**	**49%**	**7,0**	36,4	0,0	0,0	0,0	0,0	**1,1**	**2,7**	**3,3**	**4,3**	**5,5**	**8,5**	**9,5**	**11,6**	**16,9**
	Conventional	40%	**7,0**	43,0	0,0	0,0	0,0	**0,6**	**2,9**	**4,9**	**5,6**	**6,9**	**8,3**	**11,9**	**13,2**	**15,8**	**22,3**
Coal	Modern	40%	**15,0**	31,2	0,0	0,0	0,0	0,0	**1,6**	**5,0**	**6,2**	**8,3**	**10,7**	**16,7**	**18,8**	**23,2**	**34,1**
	Average	**37%**	**15,0**	32,5	0,0	0,0	0,0	0,0	**2,9**	**6,6**	**7,9**	**10,2**	**12,8**	**19,3**	**21,6**	**26,3**	**38,1**
	Old	35%	**15,0**	33,5	0,0	0,0	0,0	0,0	**4,0**	**7,9**	**9,2**	**11,6**	**14,4**	**21,3**	**23,7**	**28,6**	**41,1**

The actual windfall profits depend on the marginal power plants for each regional market spread over the annual load curve. The regional character implies that the same fuel switches occur in all market at the same time. This means that windfall profits differ from region to region.

V.5 Cap & trade at a higher price differential between coal & gas

The price differential between coal and natural gas has a great impact on the fuel switch prices and hence on the market price for CO_2 and the occurrence of windfall profits. This is demonstrated for a price differential which may emerge soon as gas prices are soaring:

Cap & trade High price differential coal - gas

Full delivered fuel prices	€/GJ	
Coal	**1,8**	38%
Gas	**4,7**	

Merit order	1	2	3	4	5
	Cheapest			Most expensive	

SRMC = Short Run Marginal Cost

Fuel	Technology	Efficiency	ton CO_2 per MWh	Fuel cost €/MWh	5 SRMC	7,5 SRMC	10 SRMC	15 SRMC	20 SRMC	22,5 SRMC	28,9 SRMC	33,9 SRMC	42,3 SRMC	50 SRMC	55 SRMC	60,5 SRMC	76,5 SRMC
					CO₂-price (EURO/ton)					Switch:	I	II	III			IV	V
Gas	**CCGT average**	**49%**	**0,41**	34,5	36,6	37,6	38,7	40,7	42,8	43,8	**46,4**	**48,5**	**51,9**	55,1	57,2	59,5	66,1
	Conventional	40%	**0,50**	42,3	44,8	46,1	47,3	49,9	52,4	53,7	56,9	59,4	63,6	67,5	70,1	**72,8**	**80,9**
	OCGT	35%	**0,58**	48,3								67,9					
Coal	Modern	40%	**0,85**	16,2	20,4	22,5	24,7	28,9	33,1	35,2	40,6	44,9	**51,9**	58,5	62,7	67,4	**80,9**
	Average	**37%**	**0,91**	17,5	22,1	24,4	26,7	31,2	35,8	38,1	43,9	**48,5**	56,2	63,2	67,8	**72,8**	**87,5**
	Old	35%	**0,97**	18,5	23,3	25,8	28,2	33,0	37,9	40,3	**46,4**	51,3	59,4	66,9	71,7	77,0	92,5

Fuel	Technology	Efficiency	Opportunity-cost in €/MWh (SRMC - fuel cost):												
Gas	**CCGT average**	**49%**	2,1	3,1	4,1	6,2	8,2	9,3	**11,9**	**14,0**	**17,4**	20,6	22,7	24,9	31,5
	Conventional	40%	2,5	3,8	5,0	7,6	10,1	11,4	14,6	17,1	21,3	25,2	27,8	**30,5**	**38,6**
Coal	Modern	40%	4,2	6,3	8,5	12,7	16,9	19,0	24,4	28,7	**35,7**	42,3	46,5	51,2	**64,7**
	Average	**37%**	4,6	6,9	9,1	13,7	18,3	20,6	26,4	**31,0**	38,6	45,7	50,3	**55,3**	**70,0**
	Old	35%	4,8	7,3	9,7	14,5	19,3	21,8	**27,9**	32,7	40,9	48,3	53,2	58,5	74,0

The 2nd switch price has now increased from € 23.6/ton of the previous section to € 33.9/ton. The consequences of cap & trade – when gas is more expensive – on the gross margins and the market prices for electricity are presented in the following table:

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[8] As explained, in a case C approach the windfall profits would be much higher.

Fuel	Technology	Efficiency		Fuel + gross margin	CO$_2$-price (EURO/ton) 5	7,5	10	15	20	22,5 Switch	28,9 I	33,9 II	42,3 III	50	55	60,5 IV	76,5 V
Cap & trade																	
	Competitive gross margins		€/MWh	€/MWh	Gross margin: either € 7 or 15/MWh or opportunity-cost, whatever is higher €/MWh												
Gas	CCGT average	49%	7,0	41,5	7,0	7,0	7,0	7,0	8,2	9,3	11,9	14,0	17,4	20,6	22,7	24,9	31,5
	Conventional	40%	7,0	49,3	7,0	7,0	7,0	7,6	10,1	11,4	14,6	17,1	21,3	25,2	27,8	30,5	38,6
Coal	Modern	40%	15,0	31,2	15,0	15,0	15,0	15,0	16,9	19,0	24,4	28,7	35,7	42,3	46,5	51,2	64,7
	Average	37%	15,0	32,5	15,0	15,0	15,0	15,0	18,3	20,6	26,4	31,0	38,6	45,7	50,3	55,3	70,0
	Old	35%	15,0	33,5	15,0	15,0	15,0	15,0	19,3	21,8	27,9	32,7	40,9	48,3	53,2	58,5	74,0

Fuel	Technology	Efficiency		Fuel + CO2 cost + margin	CO$_2$-price (EURO/ton) 5	7,5	10	15	20	22,5 Switch	28,9 I	33,9 II	42,3 III	50	55	60,5 IV	76,5 V
Cap & trade																	
	Competitive gross margins		€/MWh	€/MWh	Market price: with gross margin € 7 or 15/MWh or opportunity-cost, whatever is higher €/MWh												
Gas	CCGT average	49%	7,0	41,5	41,5	41,5	41,5	41,5	42,8	43,8	46,4	48,5	51,9	55,1	57,2	59,5	66,1
	Conventional	40%	7,0	49,3	49,3	49,3	49,3	49,9	52,4	53,7	56,9	59,4	63,6	67,5	70,1	72,8	80,9
Coal	Modern	40%	15,0	31,2	31,2	31,2	31,2	31,2	33,1	35,2	40,6	44,9	51,9	58,5	62,7	67,4	80,9
	Average	37%	15,0	32,5	32,5	32,5	32,5	32,5	35,8	38,1	43,9	48,5	56,2	63,2	67,8	72,8	87,5
	Old	35%	15,0	33,5	33,5	33,5	33,5	33,5	37,9	40,3	46,4	51,3	59,4	66,9	71,7	77,0	92,5

From this analysis it is clear that with a higher price differential between coal and gas the market is pushed to price levels where higher windfall profits will occur:

Fuel	Technology	Efficiency			CO$_2$-price (EURO/ton) 5	7,5	10	15	20	22,5 Switch	28,9 I	33,9 II	42,3 III	50	55	60,5 IV	76,5 V
Cap & trade																	
	Competitive gross margins		€/MWh	Margins €/MWh	Cap & trade windfall profits: margin above competitive margins €/MWh												
Gas	CCGT average	49%	7,0	7,0	0,0	0,0	0,0	0,0	1,2	2,3	4,9	7,0	10,4	13,6	15,7	17,9	24,5
	Conventional	40%	7,0	7,0	0,0	0,0	0,0	0,6	3,1	4,4	7,6	10,1	14,3	18,2	20,8	23,5	31,6
Coal	Modern	40%	15,0	15,0	0,0	0,0	0,0	0,0	1,9	4,0	9,4	13,7	20,7	27,3	31,5	36,2	49,7
	Average	37%	15,0	15,0	0,0	0,0	0,0	0,0	3,3	5,6	11,4	16,0	23,6	30,7	35,3	40,3	55,0
	Old	35%	15,0	15,0	0,0	0,0	0,0	0,0	4,3	6,8	12,9	17,7	25,9	33,3	38,2	43,5	59,0

V.6 Percentages pass through

As mentioned, opportunity-cost always need to be taken into account for 100% (see section V.8). Following tables are based on case A. The other cases have worse results.

Fuel	Technology	Efficiency			CO$_2$-price (EURO/ton) 5	7,5	10	15	20	22,5 Switch	28,9 I	33,9 II	42,3 III	50	55	60,5 IV	76,5 V
Cap & trade																	
	Competitive gross margins		€/MWh	Margins €/MWh	Cap & trade: pass through of opportunity-cost €/MWh (= higher margin / opportunity-cost)												
Gas	CCGT average	49%	7,0	7,0	0%	0%	0%	0%	15%	25%	41%	50%	60%	66%	69%	72%	78%
	Conventional	40%	7,0	7,0	0%	0%	0%	8%	31%	38%	52%	59%	67%	72%	75%	77%	82%
Coal	Modern	40%	15,0	15,0	0%	0%	0%	0%	11%	21%	39%	48%	58%	65%	68%	71%	77%
	Average	37%	15,0	15,0	0%	0%	0%	0%	18%	27%	43%	52%	61%	67%	70%	73%	79%
	Old	35%	15,0	15,0	0%	0%	0%	0%	22%	31%	46%	54%	63%	69%	72%	74%	80%

It is clear that the percentage of the pass through of the opportunity-costs increases fast when CO_2-prices increase. Certainly above € 20/ton, each <u>additional</u> amount of opportunity-cost comes 100% in the electricity price. The effects of the gross margins compared to historical margins quickly become significant above € 20/ton CO_2:

Fuel	Technology	Efficiency			CO$_2$-price (EURO/ton) 5	7,5	10	15	20	22,5 Switch	28,9 I	33,9 II	42,3 III	50	55	60,5 IV	76,5 V
Cap & trade																	
	Competitive gross margins		€/MWh	Margins €/MWh	Cap & trade: gross margins above (assumed) historical margins €/MWh (= higher margin / historical margin)												
Gas	CCGT average	49%	7,0	7,0	0%	0%	0%	0%	18%	32%	70%	99%	149%	194%	224%	256%	351%
	Conventional	40%	7,0	7,0	0%	0%	0%	8%	44%	62%	108%	144%	205%	261%	297%	336%	452%
Coal	Modern	40%	15,0	15,0	0%	0%	0%	0%	13%	27%	63%	91%	138%	182%	210%	241%	332%
	Average	37%	15,0	15,0	0%	0%	0%	0%	22%	37%	76%	107%	158%	205%	235%	269%	367%
	Old	35%	15,0	15,0	0%	0%	0%	0%	29%	45%	86%	118%	172%	222%	255%	290%	393%

V.7 Electricity price discovery

Electricity prices in one Member State may exceed the break-even price of the power plants that actually execute fuel switch in another Member State. This is illustrated by examples of the colourful table of section V.3.

Assume that a 40% gas-fired plant is needed as marginal plant (during daylight working days) in the Netherlands; then CCGT plants in the Netherlands run at maximum and cannot replace coal plants. The CO_2-price could be set in Germany where average CCGT plants replace older coal plants of 35% efficiency, so let's assume at € 28.9/ton. This situation results in an electricity price in the Netherlands of € 56.9/MWh (see conventional 40% gas-fired plant), which exceeds the price of the CCGT plant in Germany with € 10.5/MWh. In this case the import capacity of electricity from Germany to the Netherlands runs at maximum.

In another situation the 2nd switch may occur at € 33.9/ton in the UK. But in Germany older coal plants may be needed to deliver the demand in the market, assume lignite plants with an emission of 1.0 ton CO_2/MWh. The German price will then be € 53.2/MWh, which exceeds the fuel switch price with € 4.7/MWh. Average CCGT plants in Germany run then at maximum capacity.

In conclusion, in the scattered regional European markets with transport constraints electricity prices will often exceed the price of a fuel switch which is actually taking place. This means that the economic rent for the EU as a whole will often be (significantly) higher than expected from a straightforward calculation.

V.8 The example of the German power market

The effect of increasing electricity market prices is illustrated by the example of the German market (source Fortis Bank):

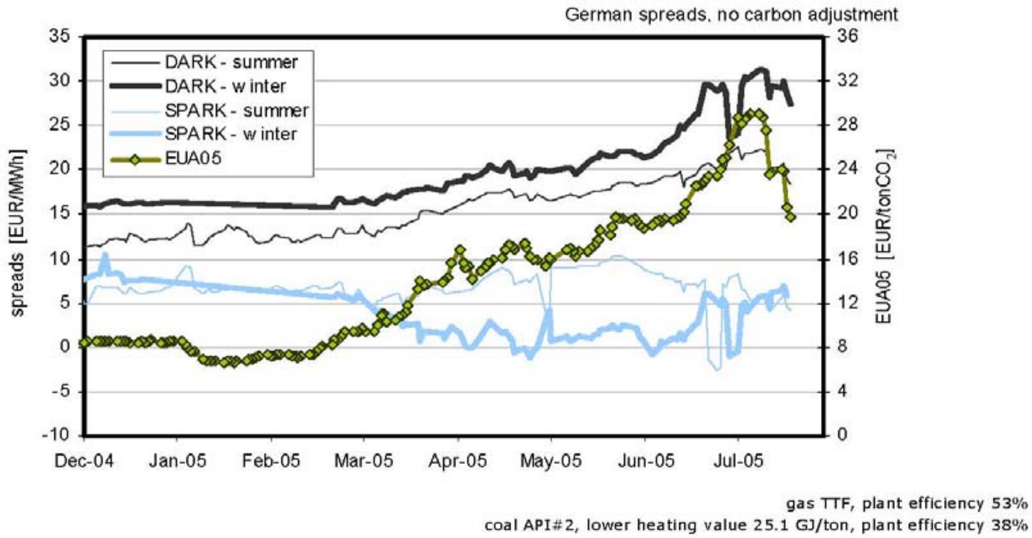


Figure 2 : Emission certificates forwards and historical spark/dark spreads, non-carbon adjusted

Until March the dark[9] spreads are not affected; when the CO_2-price is higher than € 15/ton the dark spread increases as well. Please bear in mind that in Germany **marginal plants affecting the winter dark spread are lignite plants** with an emission of about **1.1 ton CO_2/MWh or higher**, thus more than 0.97 ton CO_2/MWh of the old plant in the model above.

These observations seem to point at a case A approach. Further it is assessed that the shortage of allowances for German electricity producers is rather low – estimated[10] 3% - which also seem to support a case A behaviour. However, another explanation could be that the complex effects of emissions trading were still being discovered, in which case the calculation rules of the mathematical (mixed integer linear programming) models were only established as from about March 2005 and this could be a main reason that CO_2-prices and electricity prices started to rise.

Anyhow, the presented dark spread calculations are based on a 38% efficiency coal plant, which is similar to the 37% efficiency plant is the presented model. But with marginal plants of 1.1 ton CO_2/MWh a higher spread can be expected. A few points of the winter dark spread:

- At € 16/ton in April a spread of € 18/MWh could be expected. This seems OK.
- At € 20/ton in June a spread of € 22/MWh is expected. This seems OK as well.
- At € 24/ton in July € 28-29/MWh is expected and seen.
- It is strange that this spread falls in about one day in July while the CO_2-price is about € 26/ton and still rising. A few days later the spread is again on € 30/MWh.
- During the last data points of July the spread is about € 27/MWh while the CO_2-price is € 20/ton. This is higher than expected.

[9] Dark spread is the gross margin of coal-fired power plants, long term marginal cost about € 20/MWh
[10] Energy Focus Electricity, estimates on personal authority by Franck Schuttelaar, Gaselys, September 2005;

The spark[11] spreads are not (yet) affected. This may have various reasons:
1) Fuel switch is hardly occurring in 2005. The probable reason is that 2005 might be in the reference period for the amount of allowances in the 2nd 5-year trading period 2008-2012. Another factor may be coal contracts with take or pay clauses (purchase obligations). Anyhow, for example RWE has announced that they need to buy about 16 Mton allowances this year, this indicates without switching to gas.
2) Gas prices of electricity generators often have a coal component, either directly or via an indexation.
3) Contract gas prices have e delay when oil prices change.

Therefore, the spark spreads are probably higher than calculated in the figure above. The lowering of the winter spark spread from March 2005 until May 2005 may be caused by higher spot versus contract prices for natural gas.

Spot or contract gas prices relevant for fuel switch?

The assumed gas prices for fuel switch are the spot prices. This seems most relevant when spot prices are higher than contract prices.

When spot prices are lower than contract prices, the spot prices are most likely still relevant for fuel switch. The real cost of fuel switch are then also linked to the spot prices.

In both cases more gas is needed after the fuel switch.

In sum, spot prices are the relevant gas prices for fuel switch and contract prices for gas are most relevant for determining the spark spreads (gross margins) that are realised.

[11] Spark spread is the gross margin of gas-fired power plants, long term marginal cost about € 10/MWh

V.9 Cap & trade as root cause of windfall profits, violation of the Directive

It is often claimed that electricity producers make an unjustified profit because the producers received for free typically 95% allowances compared to their need. In itself this claim is true. The emissions trading Directive forbids unduly favouring of companies or sectors (Annex III, item 5). If this occurs through the implementation of the Directive, windfall profits would be a violation of the Directive.

However, the root cause of <u>these</u> windfall profits is not the behaviour of electricity producers but the allocation method of cap & trade. If the market price is lower than the fuel cost + the opportunity-cost a producer cannot produce electricity. Then it is more profitable to sell allowances.

If market prices are higher, then a reason <u>could</u> be abuse of dominant market position.

The consequences of cap & trade are demonstrated in the model (market price € 4/MWh below fuel cost + opportunity-cost of the second switch, assuming these plants are marginal):

Market share shifts between producers with the same fuel and efficiency													
Assume equilibrium for allowances	Producer	Efficiency			Assume market price below opportunity-cost	Market share	Income above fuel cost	Market share change	Effect of market share shifts Allowances purchases			Margin of winning or losing market share	
		CO2-price 33,9	Ton CO2 per MWh	Fuel cost €/MWh	€/MWh	Mwe	€ mln/year	Mwe	kton CO2	€ mln/year	marginal Mwe €/MWh	€/MWh	€ mln/year
Gas	A	49%	0,41	34,5	44,5	500	44	550	181	6,1	14,0	-4,0	-2
	B	49%	0,41	34,5	44,5	500	44	450	-181	-6,1	14,0	-4,0	2
Coal	C	37%	0,91	17,5	44,5	500	118	550	401	13,6	31,0	-4,0	-2
	D	37%	0,91	17,5	44,5	500	118	450	-401	-13,6	31,0	-4,0	2

Conclusions market functioning of cap & trade:

- Winning market share at a market price below fuel cost + opportunity-costs leads to a loss of total margin (€ -2 mln in the table) while losing market increases the total margin, contrary to what happens without caps.
- Therefore, a producer cannot sell electricity below fuel + opportunity-costs.
- Opportunity-costs serve as a cushion for a guaranteed minimum gross margin.
- This leads to windfall profits as demonstrated.

V.10 Competition rules and cap & trade

Under cap & trade, winners of market share must buy allowances (or can sell fewer allowances) while losers of market share sell (or buy fewer) allowances.
At a market price of fuel cost + opportunity-cost this turns out to be a zero sum game:

Market share shifts between producers with the same fuel and efficiency													
Assume equilibrium for allowances	Producer	Efficiency			Assume market price at opportunity-cost	Market share	Income above fuel cost	Market share change	Effect of market share shifts Allowances purchases			Margin of winning or losing market share	
		CO2-price 33,9	Ton CO2 per MWh	Fuel cost €/MWh	€/MWh	Mwe	€ mln/year	Mwe	kton CO2	€ mln/year	marginal Mwe €/MWh	€/MWh	€ mln/year
Gas	A	49%	0,41	34,5	48,5	500	61	550	181	6,1	14,0	0,0	0
	B	49%	0,41	34,5	48,5	500	61	450	-181	-6,1	14,0	0,0	0
Coal	C	37%	0,91	17,5	48,5	500	136	550	401	13,6	31,0	0,0	0
	D	37%	0,91	17,5	48,5	500	136	450	-401	-13,6	31,0	0,0	0

Member States are not supposed to hinder a competitive market or to violate the principle of equal treatment when they grant allowances to undertakings:

"In the case of public undertakings and <u>undertakings to which Member States grant special or exclusive rights</u>, Member States shall neither enact nor maintain in force any measure contrary to the rules contained in this Treaty, in particular to those rules provided for in Article 12 [principle of non-discrimination or equal treatment] and Articles 81 to 89" (EC Treaty Article 86).

The principle of equal treatment is not obeyed because electricity producers receive a transfer of wealth at the expense of electricity users.

Violations of the EC Treaty competition rules can occur with the following articles:

- Article 81 (undistorted competition);
- Article 82 (dominant position);
- Article 87 (state aid).

The findings of the effects induced by cap & trade on the functioning of undistorted competition are summarised in the following three tables:

EC Treaty Article 81	**Findings of cap & trade**
1. The following shall be prohibited as incompatible with the common market: all agreements between undertakings, decisions by associations of undertakings and **concerted practices which may affect trade between Member States and which have as their** object or **effect the** prevention, restriction or **distortion of competition within the common market**, and in particular those which: (a) **directly or indirectly** fix purchase or selling prices or any other trading conditions; (b) **limit or control production, markets, technical development**, or **investment**; (c) share markets or sources of supply; (d) apply dissimilar conditions to equivalent transactions with other trading parties, thereby placing them at a competitive disadvantage; (e) make the conclusion of contracts subject to acceptance by the other parties of supplementary obligations which, by their nature or according to commercial usage, have no connection with the subject of such contracts.	The unconditional allocation of emission allowances in all Member States under cap & trade is a **concerted practice** imposed by Member States that will affect trade between Member States. This concerted practice has main consequences: **(1) Winners of market share – for example producers of cement, steel or electricity, falling under the trading scheme – have to buy allowances** (or can sell fewer allowances) when they want to realise the additional market share. **This will affect and distort the trade between Member States** as there is a lively competitive common market. Producers also compete for export markets outside the EU-25 and then the distorting effect is the same between competitors in different Member States. This is also valid for electricity producers as long as prices are above the level of fuel cost plus opportunity-cost, which easily occurs in practice. **(2) Producers of electricity are forced to fully charge the opportunity-cost,** which means that winning or losing market share has turned into a zero sum game; the reason is that producing or not producing gives the same result for producers in terms of cash flow. This effect distorts competition between Member States as **undistorted competition is characterised** by the **ability to improve the cash flow** of a producer **by winning market share** through better marketing **and/or by offering lower, more competitive prices. The latter is prohibited** by this particular **concerted practice** in the form of unconditional allocation of allowances (the cap).

In sum, the concerted practice of cap & trade distorts competition and enhances frozen market shares when producers seek to win market share by competing on margins. Therefore, the functioning of the market is clearly hindered by this method of allocation. The distortions increase as CO_2-prices increase.

The market shares concerned are those that were present during the (arbitrary, and thus different in different Member States) historical reference period that was used for granting the cap. Producers will seek additional market share, for example when they had an unlucky low market share in the reference period or when they extend production capacity step by step by eliminating small bottlenecks of their process (“capacity creep”).

EC Treaty Article 82	Findings of cap & trade
Any **abuse** by one or more undertakings **of a dominant position** within the common market or in a substantial part of it shall be prohibited as incompatible with the common market in so far as it may affect trade between Member States. Such abuse may, in particular, consist in: a. **directly or indirectly imposing unfair** purchase or **selling prices** or other unfair trading conditions; b. **limiting** production**, markets** or **technical development** to the prejudice of consumers; c. applying dissimilar conditions to equivalent transactions with other trading parties, thereby placing them at a competitive disadvantage; d. making the conclusion of contracts subject to acceptance by the other parties of supplementary obligations which, by their nature or according to commercial usage, have no connection with the subject of such contracts.	By applying the cap & trade system the Member State governments have brought electricity producers in a **dominant position**, **also caused by the absence of competition with producers outside the EU-25,** in which they are **economically forced to charge substantial higher prices** than in the absence of cap & trade emissions trading. Due to this **forced dominant position** each electricity producer cannot economically produce below fuel cost plus opportunity-cost. Therefore, **producers of electricity are forced to fully charge the opportunity-cost,** the **dominant position** imposed by Member States has caused the producers to charge **unfair selling prices.** This effect distorts competition between Member States as **free competition is characterised** by the **ability to improve the cash flow** of a producer **by winning market share** through better marketing **and/or by offering lower, more competitive prices. The latter is prohibited** by this particular form of unconditional allocation of allowances (the cap). In conclusion, the method of allocation as indicated above leads to **unfair selling prices and limitation of market competition**.

In sum, this special kind of abuse of dominant position is caused and imposed by the Member States, which have enacted the measure of cap & trade.

Articles 81 and 82 mention also “limit … technical development …”. This issue is also relevant under cap & trade and addressed in section V.16 (page 27).

Another possibility of abuse of dominant position may for example be when producers keep marginal plants rather inefficient. This practice would result in higher margins for all power plants with lower short run marginal costs. This can be done in the short term during operations (by limiting production of more efficient plants) as well as in the long term by refraining from investments to improve efficiency of existing plants or by replacing existing plants by higher efficiency plants. This dominant position could be exploited because of high entry barriers in the electricity market.

This kind of possible effects of dominant positions (or concerted practices) by deliberately refraining from competitive actions is not studied and therefore completely outside the scope of this paper. One element, the effect of cap & trade on efficiency improvement, is discussed later in this study.

EC Treaty Article 87	Findings of cap & trade
1. Save as otherwise provided in this Treaty, **any state aid** by a Member State or through State resources **in any form whatsoever which distorts or threatens to distort competition** by favouring certain undertakings or the production of certain goods shall, **insofar as it affects trade between Member States,** be incompatible with the common market.	Granting allowances free of charge is considered to be state aid by the Commission (Commission decisions on the CO_2-trading schemes of Denmark and UK and the NOx-trading scheme of the Netherlands). The particular state aid in the form of unconditional allocation of allowances has two consequences: **(1) Winners of market share – for example producers of cement, steel or electricity, falling under the trading scheme – have to buy allowances** (or can sell fewer allowances) when they want to realise the additional market share. **This mechanism will affect and distort the trade between Member States** as there is a lively competitive common market. Producers also compete for export markets outside the EU-25 and then the hampering effect is the same between competitors of different Member States. **(2) Producers of electricity are forced to fully charge the opportunity-cost,** which means that winning or losing market share has turned into a zero sum game; the reason is that producing or not producing gives the same result for producers in terms of cash flow. **This effect distorts competition between Member States** as **competition is characterised** by the **ability to improve the cash flow** of a producer **by winning market share** through better marketing **and/or by offering lower, more competitive prices. The latter is prohibited** by this particular state aid in the form of unconditional allocation of allowances (the cap).

In sum, this particular form of state aid affects and distorts the trade between Member States. The Council could accept this state aid (Article 88); this possibility is absent for Articles 81 and 82.

V.11 Considerations about opportunity-costs

Cap & trade causes opportunity-costs and in economic literature this is regarded as an advantage from the point of view of market demand of the products concerned[12]. Due to the price-elasticity of demand, the demand is lower if compared to systems with a lower price effect. In this literature absolute targets are judged superior to relative systems, also because of arguments such as certainty of the environmental outcome and market liquidity[13].

Price-elasticity of the demand is indeed an argument in favour of cap & trade causing a lower product demand by the opportunity-cost (as for auctioning, causing real cost). But the effects are most likely rather limited at CO_2-prices in the range of € 20-60/ton. For example, in the recent 10 years many costly new products like mobile telephones, personal computers and far distance holiday travels around the globe increased penetration beyond earlier expectations as welfare increased.

Fact is that economists have entirely different views on the magnitude of the price-elasticity on the demand of products and many assume a low elasticity[14].

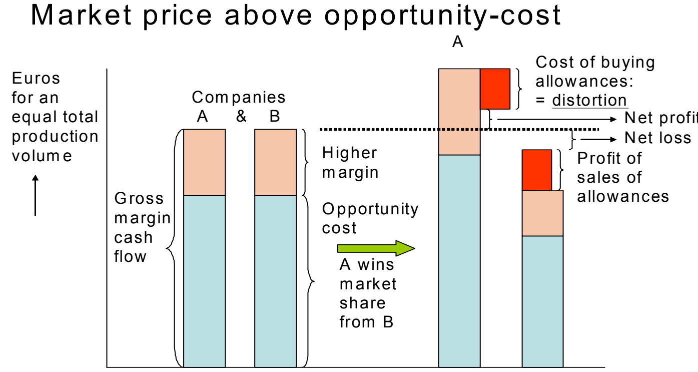
But the same economic literature ignores the dynamics of a free market in which successful firms win market share on the basis of better marketing, better tailored final products and by competing on margins. For example, in air travel low cost carriers have won a substantial amount of market share from traditional carriers.

For industrial companies falling under the emissions trading scheme market dynamics will also play an important role, market share advances of innovative companies with a better efficiency will bring total emissions down.

But what happens with a winner of market share? First we assume that the market price of a product is above variable + opportunity-cost. For reasons of comparison two companies are considered having the same production, same efficiency and the same amount of allowances:

Due to the caps company A must buy allowances and company B will sell allowances as a result of the markets share shift. Company A is penalised by the cost of buying allowances, it has to “pay” this penalty to company B. This is the distortion of competition.

Market price above opportunity-cost



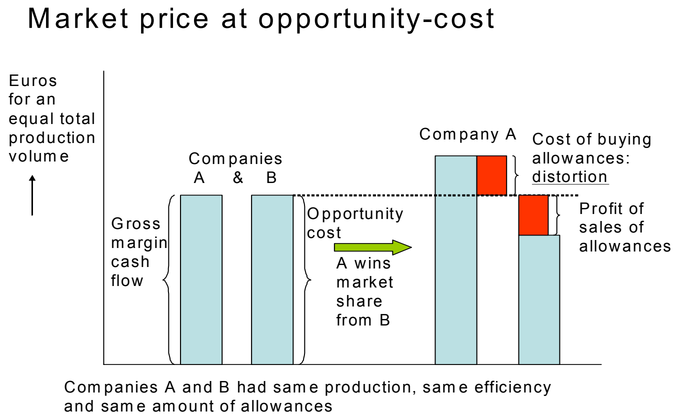
Companies A and B had same production, same efficiency and same amount of allowances

When CO_2-prices increase the opportunity-cost will also increase and the variable cost + opportunity-cost can become equal to the market price. Another cause can be that the

[12] See for example A. Gielen, P. Koutstaal and H.R.J. Vollebergh (2002) *Comparing emissions trading with absolute and relative targets*. London: paper presented to the second CATEP Workshop, 25-26 March 2002.
[13] These arguments are discussed in the paper *Climate change challenges and the search for a sustainable policy*, presented at the 8th International Conference on Carbon Dioxide Utilization (ICCDU-VIII), 21 June 2005, Vianney Schyns, Utility Support Group, utility provider for DSM & SABIC
[14] See for example *Climate Change Policies, international trade and carbon leakage: an applied general equilibrium analysis*, O. Kuik, 9 September 2005.

market price comes down due to lower demand and increased competition in the market. The following picture emerges:

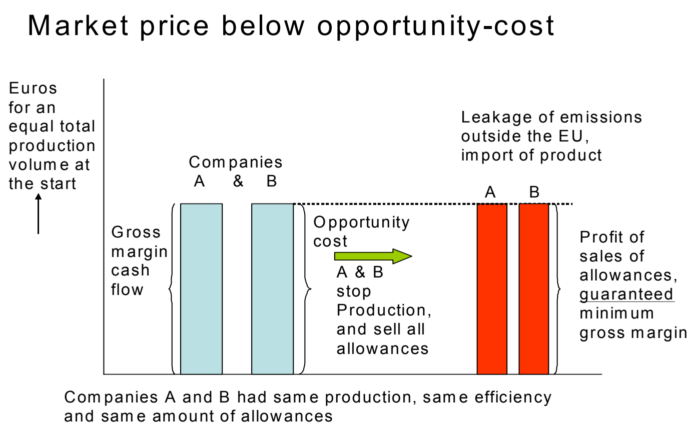
Winning and losing market share has become a zero sum game. This is valid for electricity as well as for any other product such as steel, cement, etc. Cement is already a market with sharp margins and for steel the current favourable market conditions could change.



Unlike electricity, products competing on the global market can be faced with a market in which the market price is lower than variable costs + opportunity-cost:

The economical decision of companies A & B is then to lower production and sell allowances, ultimately until a production of zero.

Lowering production will not happen in a year that might be part of a historical reference for a next trading period; shutting down the plant completely will also not happen in most Member States because after closure no allowances are available anymore[15].



In sum, this type of opportunity-costs caused by cap & trade, shows several characteristics:

- Distortions of competition occur when producers seek to win market shares. Competing on margins becomes more difficult as the final result may end close to or up to zero, thus frozen market shares are enhanced.
- When the market price is equal to variable cost + opportunity-cost winning or losing market share has turned into a zero sum game. There is no possibility anymore to compete on margins. This situation causes a restriction of competition.
- Opportunity-costs tend to work as a guaranteed minimum margin, for example € 300 mln/year for a (steel) site with 10 Mton/year allowances at a price of € 30/ton CO_2.
- Opportunity-costs are therefore the root cause of leakage of emissions, contrary to the spirit and the aim of the Directive (see also recital 3 of the Directive).

These features are enacted by a measure of the Member States, the measure to grant a frozen amount of allowances to individual producers without regard for future production. Most remarkable is that the cap & trade measure imposed by the state tends to cause a minimum gross margin, which is significant for energy-intensive products at a meaningful CO_2-price.

15 Although the precise rules differ from one Member States to another, temporary shut down or production in campaigns if often not considered a reason to withhold allowances.

These features, except leakage of emissions, occur equally when cap & trade would be applied on a global scale. Other notable features such as letting new entrants buy all needed allowances – a normal practice according to the theory of cap & trade and what can easily happen with capped (limited) reserves or because of arbitrary thresholds to qualify for a reserve as currently applied in various Member States – would lead to barriers of entry.

The features of cap & trade go beyond legal problems of a distributional nature as they have a significant impact on the effectiveness of a trading scheme. The economic charms of cap & trade are high-jacked by distributional and legal imperatives. Cap & trade hinders innovative market shares winners, it petrifies the status quo.

These negatives show that cap & trade is also no feasible approach on a global scale.

V.12 Shortcomings of current rules for Combined Heat & Power

Combined Heat & Power (CHP) would be stimulated by the current allocation rules because of the increased prices for electricity. However, windfall profits are not perceived sustainable as they are against the requirements of the Directive as mentioned above.

CHP would need a favourable allocation in a sustainable scheme, but current allocation rules do not provide such a stable and predictable basis as grandfathering is most often applied. Current allocation rules do not or hardly stimulate CHP, while this is requested by the Directive (recital 20).

Fuel-specific benchmarks as applied in the Netherlands (based on gas, 50% efficiency for electricity and 90% efficiency for the usefully applied heat) do provide some stimulus, but this is limited by a maximisation rule (maximum 110% compared to these benchmarks) and anyway not enough to stimulate additional investments in CHP. In addition, CHP as a new entrant receives no encouragement (allowances "never more than needed") and the general reduction factor (“C-factor”) even means that some allowances must be bought.

V.13 Shortcomings of current rules for coal and lignite power plants

The objective function – fitness for purpose – is not served by the current allocation rules for coal and lignite power plants.

Firstly, the incumbent coal and lignite plants receive a relatively high allocation, by historical grandfathering or by a fuel-specific benchmark[16], while these plants are high polluters if compared to gas-fired plants in general and CHP in particular.

Secondly, new entrant coal or lignite plants get under current allocation rules most often the amount of allowances they need, provided state-of-the-art technology is applied. Imagine what happens: emissions must go down while new coal and lignite plants continue be built.

As a consequence, the high allocation to especially new coal and lignite plants would lead to much more severe general reduction factors (“C-factor”) to the detriment of other sectors.

Various plans for new coal and lignite power plants are under study in Europe[17]. These plants need an economical life of at least 40 years, so they would be there beyond 2050. And one has to keep in mind that the demand for electricity grows by 1.5%-1.7%/year.

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[16] Fuel-specific benchmarks on historical emissions (2001 and 2002) were applied in the Netherlands to determine the cap for each installation producing electricity.

[17] In Germany various plans are announced, one plant would emit around 22 Mton/year. In the Netherlands three new plants are considered. There are possibly also plans in other Member States.

This leads to the conclusion that the additional emissions caused by new coal and lignite power plants under consideration could be about equal to the forecasted reduction of the 1st trading period of about 50 Mton CO_2/year.

V.14 Quantification of shortcomings for current CHP, coal and lignite rules

Without a change of the allocation rules, serious economic damage could result if compared to allocation rules which support the carbon constraint. This is elaborated below. Nevertheless, at the end of this analysis two policy arguments are presented for a limited number of high efficiency coal- and lignite-fired power plants.

Based on Eurostat data the split of emissions was estimated for 2002:

EU-25	Efficiency estimates	ton CO_2 per MWh	Estimates	**Eurostat 2002**	ton CO_2 per MWh	ton CO_2 per MWh estimated
Coal incl. lignite	**36%**	**0,94**		30%		0,94
Gas CHP	80%	0,25	7,0%		0,25	
Gas CCGT	49,5%	0,41	10,0%		0,41	
Gas boiler	40%	0,50	0,8%		0,50	
Gas OCGT	33%	0,61	0,2%		0,61	
Gas total EU-25	**57%**	**0,35**	**18,0%**	18%		0,35
Oil	**38%**	**0,71**		6%		0,35
Total fossil				**54%**		**0,680**
Nuclear		0		32%		
Renewables		0		13%		
Other		0		1%		
Grand total				**100%**		**0,367**

Based on this estimation the outcome of the 1st trading period if compared to a business as usual scenario is assessed:

EU-25	**Estimates 2007 Business as usual** TWh	Split total	Emission CO2 Mton	Fuel PJ	Fuel units	**Change 2005 - 2007 by fuel switch, cap & trade (assume 50 Mton/year reduction of emissions)** TWh	Change TWh	CO2 Mton	Fuel PJ	Change fuel use
Coal incl. lignite	805	25%	757	8.050	316	-105	-12%	-99	-1050	-12%
Gas CHP	270	**8,5%**	68	1.215	38	54	25%	14	243	25%
Gas CCGT	425	13%	173	3.091	98	116	38%	47	844	38%
Gas boiler	35	1%	18	315	10	10	40%	5	90	40%
Gas OCGT	10	0%	6	109	3	4	67%	2	44	67%
Gas total EU-25	**740**	**23%**	**265**	**4.730**	**149**	**184**	**33%**	**68**	**1220**	**35%**
Oil	150	5%	107	1.421	36	-28	-16%	-20	-265	-16%
Total fossil	**1.695**	**54%**	**1.129**	**14.201**		**51**	**3,1%**	**-50**	**-95**	
Nuclear	975	31%	0	0		16	1,7%	0	0	
Renewables	465	15%	0	0		36	8,4%	0	0	
Other	30	1%	0	0		1	3,4%	0	0	
Grand total	**3.165**	**100%**	**1.129**	**14.201**		**104**	**3,4%**	**-50**	**-95**	

In this forecast, the electricity production is increased with 104 TWh (assumed 1.7%/year). By fuel switch more gas-fired electricity and less coal-fired electricity is produced leading to a lower emission of 50 Mton/year. This is assumed as the net shortage of allowances of the 1st trading period.

For the 2nd trading period consumption growth of 1.7%/year is estimated, leading to an average consumption of 3,330 TWh per year in this period.

With a scenario that favours CHP (Combined Heat & Power) and a further carbon constraint the following effects on the use of fuels can be calculated:

Scenario with new Combined Heat & Power, still less than scenario DG TREN 2008 - 2012											
EU-25	2007		Emission	BAU 2008 - 2012			Assume target 2008-2012			Delta	Delta
			CO2	Without ETS		CO2				BAU	from 2007
	TWh		Mton	TWh		Mton	TWh		Mton		Mton
Coal incl. lignite old	805	**25%**	757	740	22%	696	705	21%	663	-33	**-94**
Coal incl. lignite new	0	0%	0	0	0%	0	0	0%	0	0	0
Gas CHP	270	9%	68	560	**16,8%**	141	560	**16,8%**	141	0	73
Gas CCGT	425	13%	173	280	8%	114	295	9%	120	6	-53
Gas boiler	35	1%	18	35	1%	18	35	1%	18	0	0
Gas OCGT	10	0%	6	10	0%	6	30	1%	18	12	12
Gas total EU-25	**740**	**23%**	**265**	**885**	**27%**	**279**	**920**	**28%**	**298**	**18**	**32**
Oil	150	5%	107	135	4%	96	135	4%	96	0	-11
Total fossil	**1.695**	**54%**	**1.129**	**1.760**	**53%**	**1.071**	**1.760**	**53%**	**1.056**	**-15**	**-72**
Nuclear	975	31%	0	1.010	30%	0	1.010	30%	0	0	0
Renewables	465	15%	0	530	16%	0	530	16%	0	0	0
Other	30	1%	0	30	1%	0	30	1%	0	0	0
Grand total	**3.165**	**100%**	**1.129**	**3.330**	**100%**	**1.071**	**3.330**	**100%**	**1.056**	**-15**	**-72**
										-1,4%	**-6,4%**

The shift from coal and lignite to natural gas is highlighted below:

Scenario with new CHP, still less than scenario DG TREN 2008 - 2012							
EU-25	**Additional fuel to achieve target**						
Average 2008-2012	From BAU	From 2007					
Electricity:	PJ	PJ			%		
Coal incl. lignite old	-350	-1.000		**Total**			
Coal incl. lignite new	0	0	**-1.000**	**coal**	**-12%**	**-39**	Mton coal / lignite
Coal incl. lignite new							
Gas CHP	0	1.305					
Gas CCGT	109	-945					
Gas boiler	0	0					
Gas OCGT	218	218		**Total**			
Gas total EU-25	**327**	**578**	**578**	**gas**	**12%**	**18**	Billion m3 gas
Oil		**CO2-price linked to substitution of coal by CCGT**					
Total fossil		**Indication:**	**€ 25-35/ton**				
Other industries							
Other industries new							
Total EU-25							
Target							

This means that under this scenario 12% more natural gas is needed if compared to the expected use in 2007. The reason for this modest increase is the high efficiency of CHP.

In contrast, current allocation rules promote new (efficient) coal and lignite power plants and CHP is hardly stimulated. This leads to the following forecast:

Scenario with modern new coal plants and hardly any new CHP 2008 - 2012											
EU-25	2007		Emission	BAU 2008 - 2012			Assume target 2008-2012			Delta	Delta
			CO2	Without ETS		CO2				BAU	from 2007
	TWh		Mton	TWh		Mton	TWh		Mton		Mton
Coal incl. lignite old	805	**25%**	757	965	29%	907	530	16%	498	-409	**-259**
Coal incl. lignite new	0	0%	0	65	2%	51	65	2%	51	0	51
Gas CHP	270	9%	68	280	**8,4%**	71	280	**8,4%**	71	0	3
Gas CCGT	425	13%	173	280	8%	114	425	13%	173	59	0
Gas boiler	35	1%	18	25	1%	13	295	9%	149	136	131
Gas OCGT	10	0%	6	10	0%	6	30	1%	18	12	12
Gas total EU-25	**740**	**23%**	**265**	**595**	**18%**	**204**	**1030**	**31%**	**411**	**208**	**146**
Oil	150	5%	107	135	4%	96	135	4%	96	0	-11
Total fossil	**1.695**	**54%**	**1.129**	**1.760**	**53%**	**1.258**	**1.760**	**53%**	**1.057**	**-201**	**-72**
Nuclear	975	31%	0	1.010	30%	0	1.010	30%	0	0	0
Renewables	465	15%	0	530	16%	0	530	16%	0	0	0
Other	30	1%	0	30	1%	0	30	1%	0	0	0
Grand total	**3.165**	**100%**	**1.129**	**3.330**	**100%**	**1.258**	**3.330**	**100%**	**1.057**	**-201**	**-72**
										-16,0%	**-6,4%**

The new high efficiency coal and lignite plants will not be affected by fuel switch. But in the absence of more CHP more fuel switch is needed between older coal and lignite plants and lower efficiency gas-fired power plants. Therefore, under the same carbon constraint the additional need for natural gas is much higher than under a scenario which favours CHP:

Scenario with modern new coal plants and hardly any new CHP 2008 - 2012							
EU-25	**Additional fuel to achieve target**						
	From BAU	From 2007					
Electricity:	PJ	PJ			%		
Coal incl. lignite old	-4.350	-2.750		**Total**			
Coal incl. lignite new	0	544	**-2.206**	**coal**	**-27%**	**-87**	Mton coal / lignite
Coal incl. lignite new							
Gas CHP	0	45					
Gas CCGT	1.055	0					
Gas boiler	2.430	2.340					
Gas OCGT	218	218		**Total**			
Gas total EU-25	**3.703**	**2.603**	**2.603**	**gas**	**55%**	**82**	Billion m3 gas
Oil		**CO_2-price linked to substitution of coal by gas boiler**					
Total fossil	**Assume**	**Indication:**	**€ 45-60/ton**		(same fuel prices as CHP scenario)		
Other industries	**EURO/GJ:**	**2.025**	**Additional gas CHP scenario**			**64**	**9115** EURO mln/year
Other industries new	**4,5**	**Indirect burden: much higher windfall profits if cap & trade remains**					
Total EU-25		**Direct burden: more severe C-factor & higher CO_2-price, especially**					
Target		**in Member States with new coal, e.g. Germany and Netherlands**					

Under the current allocation rules, a significant additional use of gas can be expected compared with a CHP scenario, in this model forecasted as:

- An increase of 55% compared with 12% for this CHP scenario.
- An additional use compared with this CHP scenario of 64 billion m^3/year, at an extra cost of gas of about € 9 billion/year, which needs to be paid by the electricity users.
- Much higher windfall profits if cap & trade continues to be applied.
- Higher direct costs for industries under the scheme caused by the necessarily higher general reduction factor ("C-factor") and by a higher CO_2-price.

In conclusion, it would seem wise to be prudent with new power plants based on coal or lignite. Anyhow, current allocation rules are not in accordance with a more prudent approach and certainly the objective function. Nevertheless, there are at least two policy arguments in favour of a limited number of new coal- or lignite power plants.

Firstly, to gain experience with ultra high efficiency plants (45% and higher), which is also important when **zero emission plants** with CCS (Carbon Capture and Sequestration) are coming into the market shortly after 2012.
Secondly, to restrict such new plants to **replacement of less efficient plants** resulting in lower emissions.

However, both policy arguments are frustrated by the present cap & trade allocation rules. These obstacles are addressed in the next two sections.

V.15 Shortcomings of current rules for zero emission power plants

Current allocation rules fail completely for zero emission power plants such as clean coal plants with CCS (Carbon Capture and Sequestration), which are now under development.

Under the current rules for new entrants, new zero emission power plants will hardly (e.g. Germany, 375 kg CO_2/MWh) or not (e.g. Netherlands) receive allowances. This will be detrimental to the return on investment; these plants need a CO_2-price of at least € 20/ton. As incumbent in the future they will receive zero allowances as well because historical emissions are used as reference in all Member States.

It has been suggested to allocate allowances based on "transferred" CO_2 (in this case the CO_2 that is captured and stored). But this solution is not feasible. Because of the objective function to lower emissions, plants with CCS would continue to be over-allocated while the total cap needs to be reduced. This would cause an inequitable shortage in other sectors (general reduction factor).

V.16 Shortcoming of current rules to stimulate efficiency

One may ask whether cap & trade stimulates producers to improve the efficiency of power plants since the result of a better efficiency of marginal power plants is a financial loss.

Assume a coal-fired plant is upgraded from 35% to 43% efficiency. There are two effects. The 1st effect that at € 28.9/ton (see table V.3) the opportunity-cost decrease (€ 6.8/MWh) is higher than the decrease of fuel cost (€ 3.4/MWh) causing a negative return on investment. The 2nd effect is that the market price will be lower for all plants when another more efficient plant with lower short run marginal costs is marginal to supply electricity to the market. The 2nd effect is present in any market, but is less likely when there is a lively competitive market. The 1st effect is an obstacle caused by cap & trade that hinders the competitive market.

V.17 Conclusions cap & trade allocation rules

- Current allocation rules run against the objective function:
  - Existing and new coal and lignite power plants are receiving a relatively high amount of allowances
  - Combined Heat & Power is hardly or not structurally stimulated
  - Current allocation rules fail for zero emission power plants in all Member States
  - Leakage of emissions outside the EU for other products than electricity will occur as soon as variable + opportunity-costs are higher than global market prices
- The objective function is further not supported as innovation and efficiency are not stimulated unambiguously. Innovative winners of market share are penalised. Efficiency improvement investments of marginal electricity plants have a negative return on investment. In the current allocation practices there are also numerous other ineffective rules, e.g. maximisation rule at 110% of the benchmark approach in the Netherlands; giving much allowances to incumbents by historical grandfathering and few allowances to efficient new entrants; thresholds to qualify for the new entrant reserve; shutting down less efficient plants and shift production to other existing plants is penalised by the caps of the latter; etc.
- No agreement with the principle of equal treatment, the electricity sector is favoured by windfall profits at the expense of the competitiveness of all other industrial sectors in an outside the scheme (example aluminium) and welfare of the consumer.
- Windfall profits are also detrimental to the worldwide level playing field; they do not meet the stipulation of the least possible diminution of economic development and employment.
- The level playing field is disturbed as similar (power) plants get a different allocation in different Member States, as it is with transfer rules in some Member States.
- Moreover, cap & trade causes serious distortions of competition by the mechanism of enhancing frozen market shares, in violation of the EC Treaty; it brings producers in a dominant position and it is state aid affecting trade between Member States.
- Cap & trade with an allocation based on historical grandfathering is not in agreement with the polluter-pays principle for the producers.

Present allocation rules are not compliant with the spirit and the requirements of the Directive emissions trading and the EC Treaty. Moreover, the negative effect of cap & trade on the competitiveness of the energy intensive industries is contrary to the Lisbon strategy.

The further price rise of natural gas makes changes all the more urgent; modification of allowances' allocation to electricity producers is needed within the 1st trading period.

In sum, the Commission and Member States can and need to undertake action to modify the implementation of the Directive.

VI Skewed allocation of allowances

VI.1 The functioning of skewed allocation

A first possible solution to avoid the transfer of wealth to electricity producers and to avoid the effect of higher electricity prices for the users is to grant fewer allowances to electricity producers and more allowances to the other sectors – a skewed allocation. To explore this option, the simplified model of case A of the two plants has been adjusted:

Cap & trade	Full delivered fuel prices				
Higher price		€/GJ		Cheapest	More expensive
differential	Coal	1,8	38%	SRMC = Short Run Marginal Cost	
coal - gas	Gas	4,7		MPCM = Market Price at Competitive Margin	

Fuel	Technology	Competitive gross margins €/MWh	Efficiency	ton CO_2 per MWh	Fuel cost €/MWh	CO_2-price (EURO/ton)											
						0	5	10	15	20	25	30	33,9	33,9	40	45	50
							MPCM or SRMC, whatever is higher:						Before switch	After switch			
						MPCM	MPCM	MPCM	MPCM	SRMC	SRMC	SRMC	SRMC	SRMC	SRMC	SRMC	SRMC
Gas	CCGT average	7,0	49%	0,41	34,5	41,5	42,3	43,1	43,9	44,8	45,6	46,9	48,5	48,5	51,0	53,1	55,1
Coal	Average	15,0	37%	0,91	17,5	32,5	34,3	36,1	37,9	39,7	41,5	45,0	48,5	48,5	54,1	58,7	63,2
Market price at high demand (€/MWh)					50%	41,5	42,3	43,1	43,9	44,8	45,6	46,9	48,5	48,5	54,1	58,7	63,2
Market price at low demand (€/MWh)					50%	32,5	34,3	36,1	37,9	39,7	41,5	45,0	48,5	48,5	54,1	58,7	63,2
Gas-fired power plant					MWe:	100	100	100	100	100	100	100	100	122	122	122	122
Emission (kton CO2/annum) assume 8000 hrs/year						330	330	330	330	330	330	330	330	403	403	403	403
Assume cap of historical emission (kton CO2/annum)					61%	201	201	201	201	201	201	201	201	201	201	201	201
Shortage of allowances (kton CO2/year)						129	129	129	129	129	129	129	129	202	202	202	202
Cost of allowances (EURO mln/annum)						0	0,6	1,3	1,9	2,6	3,2	3,9	4,4	6,9	8,1	9,1	10,1
Assume historical margin (EURO/MWh)						7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0
Historical margin without switch (EURO mln/annum)						5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6
Margin after cost allowances (EURO/MWh)						7,0	7,0	7,0	7,0	7,0	7,0	7,5	8,5	7,0	11,3	14,8	18,4
Margin after cost allowances (EURO mln/annum)						5,6	5,6	5,6	5,6	5,6	5,6	6,0	6,8	6,8	11	14,5	18,0
Windfall margin (EURO/MWh)						0,0	0,0	0,0	0,0	0,0	0,0	0,5	1,5	0,0	4,3	7,8	11,4
Coal-fired power plant					MWe:	200	200	200	200	200	200	200	200	178	178	178	178
Emission (kton CO2/annum) assume 8000 hrs/year						1463	1463	1463	1463	1463	1463	1463	1463	1300	1300	1300	1300
Assume cap of historical emission (kton CO2/annum)					61%	891	891	891	891	891	891	891	891	891	891	891	891
Shortage of allowances (kton CO2/year)						572	572	572	572	572	572	572	572	409	409	409	409
Cost of allowances (EURO mln/annum)						0	2,9	5,7	8,6	11,4	14,3	17,2	19,4	13,9	16,4	18,4	20,4
Assume historical margins depending on market place						Gross margin gas-fired:					7,0	Gross margin coal-fired when margir					15,0
Indication Netherlands:		50%	50%		Gas / coal	Gross margin coal-fired when gas-fired is marginal:											24,0
Average historical margin coal-fired electricity (EURO/MWh)						19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5
Historical margin without switch (EURO mln/annum)						31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2
Margin after cost allowances (EURO/MWh)						19,5	19,0	18,5	18,0	17,5	17,1	17,7	18,9	21,2	25,1	28,2	31,3
Margin after cost allowances (EURO mln/annum)						31,2	30,4	29,6	28,9	28,1	27,3	28,3	30,2	30,2	35,6	40,1	44,6
Windfall margin (EURO/MWh)						0,0	-0,5	-1,0	-1,5	-2,0	-2,5	-1,8	-0,6	1,7	5,6	8,7	11,8
Totals for the two power plants													Before switch	After switch			
Margin after cost allowances (EURO mln/annum)						36,8	36,0	35,2	34,5	33,7	32,9	34,3	37,0	37,0	46,7	54,6	62,5
Historical margin without switch (EURO mln/annum)						36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8
Total fuel cost (EURO mln/annum)						55,6	55,6	55,6	55,6	55,6	55,6	55,6	55,6	58,7	58,7	58,7	58,7
Cost of allowances (EURO mln/annum)						0	3,5	7,0	10,5	14,0	17,5	21,0	23,7	20,7	24,5	27,5	30,6
Windfall profits: margin - historical margin (EURO mln/annum)						0	-0,8	-1,6	-2,4	-3,1	-3,9	-2,5	0,2	0,2	9,9	17,8	25,7
Windfall profits (%)										-9%	-11%	-7%	0%	0%	27%	48%	70%
Windfall profit (€/MWh)						0	-0,33	-0,7	-1,0	-1,3	-1,6	-1,0	0,1	0,1	4,1	7,4	10,7
Average price: margin + cost of fuel + allowances (€/MWh)						38,5	39,7	40,8	41,9	43,1	44,2	46,2	48,5	48,5	54,1	58,7	63,2
Higher price of electricity by emissions trading (€/MWh)						0	1,1	2,3	3,4	4,5	5,7	7,7	10,0	10,0	15,6	20,1	24,7
Higher price of electricity by emissions trading (€ mln/year)						0	2,7	5,4	8,2	10,9	13,6	18,5	23,9	23,9	37,4	48,3	59,3
Higher fuel cost by emissions trading (€/MWh)						0	0	0	0	0	0	0	0,0	1,3	1,3	1,3	1,3
Higher cost of the allowances by Emissions trading (€/MWh)						0	1,5	2,9	4,4	5,8	7,3	8,8	9,9	8,6	10,2	11,5	12,7
Market demand (MWe)						300	300	300	300	300	300	300	300	300	300	300	300
Total cap (kton CO2/annum)						1092	1092	1092	1092	1092	1092	1092	1092	1092	1092	1092	1092
Total emission (kton CO2/annum)						1793	1793	1793	1793	1793	1793	1793	1793	1703	1703	1703	1703
Total shortage (kton CO2/annum)						701	701	701	701	701	701	701	701	611	611	611	611
Surplus of allowances of other sectors (kton CO2/annum)						611	611	611	611	611	611	611	611	611	611	611	611
Total shortage all sectors(kton CO2/annum)						90	90	90	90	90	90	90	90	0	0	0	0
Value of surplus of allowances of other sectors (EURO mln/year)						0	3	6	9	12	15	18	21	21	24	28	31
Difference with (higher electricity - higher fuel cost) (€ mln/year)						0	0	1	1	1	2	0	-3	0	-10	-18	-26

The total shortage of allowances is the same as before, but electricity producers will now cover their greater shortage by purchases from the other sectors. In this example an allocation of 61% eliminate windfall profits at this break-even price for fuel switch.

However, this solution is not suitable for a number of reasons:

- At higher CO_2-prices windfall profits emerge again.
- As the market situations are different in different European regions, there will be an unpredictable and scattered result.
- In model C windfall profits are higher, and thus more difficult to compensate. Also this aspect makes the outcome of this method uncertain.

More important are the following reasons:

- The other sectors and companies are compensated, but this compensation is linked to their own emission[18] and not to their use of electricity.
- The other sectors falling under the trading scheme consume only a part of the total electricity use – typically one third – and get for this reason overcompensation.
- As about 45% of electricity production in the EU is based on nuclear and large scale hydropower, in many Member States severe under-compensation will occur. This will happen in Member States with a significant share of nuclear and hydropower.
- Sectors outside the trading scheme receive no compensation at all. Some sectors – such as aluminium – are most affected by the windfall profits due to cap & trade emissions trading.

The arguments above hardly change if skewed allocation would be implemented with caps on the basis of benchmarks – either fuel-specific benchmarks or one uniform benchmark for fossil-fuelled electricity.

VI.2 Conclusions skewed allocation of allowances

- The problems with the objective function as outlined under cap & trade are not addressed.
- The same other shortcomings as for cap & trade are still present in this option.
- The level playing field would be improved if compared to the present cap & trade allocation rules[19].
- Skewed allocation fits better with the polluter-pays principle, but still far insufficient because of the reasons explained above.
- Skewed allocation gives some compensation to part of the electricity users, but this compensation is poorly directed for sectors falling under the scheme and absent for sectors and the consumer outside the trading scheme.

In sum, skewed allocation of allowances is no solution for the fundamental problems of cap & trade; it is no robust solution to comply with the intentions and requirements of the emissions trading Directive and the EC Treaty.

[18] In case the middle definition is applied, sectors like chemicals and food are only involved in the trading scheme with their utility emissions. Most often this means hardly any compensation with the skewed allocation method.

[19] UK has applied a limited form of skewed allocation in the 1st trading period; electricity producers are faced with a shortage of allowances of about 25%, but the other sectors were hardly compensated.

VII Auctioning

Auctioning means – in the context of this study – that the Member States do not grant allowances free of charge but sell the limited quantity of allowances to the highest bidders.

Auctioning is often mentioned as an alternative to eliminate windfall profits and to eliminate the other shortcomings of cap & trade. Without a suitable solution it is for example not possible to combine the carbon constraint while maintaining coal and lignite as major energy carriers, the latter by carbon sequestration leading to zero emission plants.

In addition, co-firing of biomass would be promoted to enable lower emissions in existing installations – for example coal and lignite plants – as well as in new power plants.

Combined Heat & Power (CHP) would also get a structural policy basis with a clear and stable incentive to become the standard where industry needs heat. The use of natural gas would be to the degree possible shift from stand-alone gas-fired plants to CHP.

Auctioning would certainly solve many shortcomings of cap & trade; it clearly complies with the objective function of the Directive and the polluter-pays principle. However, major problems remain, which means that auctioning is not feasible if applied in the EU alone:

- Auctioning is only allowed to a maximum of 5% in the 1st trading period and 10% in the 2nd trading period.
- Auctioning eliminates windfall profits only to a limited extent, as will be shown below.
- Auctioning will still cause much higher electricity prices, detrimental to the competitive position of industrial electricity users facing the global market (see recital 5, section I.2).
- An unchanged free allocation to the other sectors provides no solution for the shortcomings of cap & trade to these sectors (conflicts with the Directive and especially the EC Treaty).

Nevertheless it is important to study the effects of auctioning as auctioning is regarded as an ideal method of allocation. All problems with new entrants, closures and frozen market shares would be solved.

VII.1 Auctioning at a "normal" price differential between coal & gas

The effects on the functioning of the markets for CO_2 with respect to electricity at the same "normal" price differential between coal and gas are presented below:

Auctioning "Normal" price differential coal - gas

Full delivered fuel prices	€/GJ	
Coal	1,8	45%
Gas	4,0	

Merit order	1	2	3	4	5
	Cheapest				Most expensive

SRMC = Short Run Marginal Cost

Fuel	Technology	Efficiency	Benchmark ton CO2/MWh auctioning	Real	Fuel cost €/MWh	CO₂-price (EURO/ton) 5,2 SRMC	7,7 SRMC	12,0 SRMC	15,0	19,6 SRMC I	23,6 SRMC II	25,6 SRMC	27,5 SRMC	30,4 SRMC III	34,6 SRMC	40,0 SRMC	45,1 SRMC IV	58,0 SRMC V
								Apparent switch:										
Gas	**CCGT average**	**49%**	**0,0**	**0,41**	29,4	31,5	32,6	34,3	35,6	**37,5**	**39,1**	39,9	40,7	**41,9**	43,6	45,9	48,0	53,3
	Conventional	40%	**0,0**	**0,50**	36,0	38,6	39,9	42,0	43,6	45,9	47,9	48,9	49,9	51,3	53,5	56,2	**58,8**	**65,3**
Coal	Modern	40%	**0,0**	**0,85**	16,2	20,6	22,7	26,3	28,9	32,8	36,2	37,9	39,5	**41,9**	45,5	50,0	54,4	**65,3**
	Average	**37%**	**0,0**	**0,91**	17,5	22,3	24,6	28,5	31,2	35,4	**39,1**	40,9	42,7	45,3	49,2	54,1	**58,8**	70,6
	Old	35%	**0,0**	**0,97**	18,5	23,5	26,0	30,1	33,0	**37,5**	41,4	43,3	45,1	47,9	52,0	57,2	62,1	74,6

Fuel	Technology	Efficiency	CO2-cost in €/MWh (SRMC - fuel cost):												
Gas	**CCGT average**	**49%**	2,1	3,2	4,9	6,2	**8,1**	**9,7**	10,6	11,3	12,5	14,3	16,5	18,6	23,9
	Conventional	40%	2,6	3,9	6,0	7,6	9,9	11,9	12,9	13,9	15,3	17,5	20,2	**22,8**	**29,3**
Coal	Modern	40%	4,4	6,5	10,1	12,7	16,6	20,0	21,7	23,3	25,7	**29,3**	33,8	38,2	**49,1**
	Average	**37%**	4,7	7,1	10,9	13,7	17,9	**21,6**	23,4	25,2	27,8	31,6	36,6	**41,3**	53,1
	Old	35%	5,0	7,5	11,6	14,5	**19,0**	22,9	0,0	26,6	29,4	33,4	38,7	43,6	56,1

The fuel switch prices seem exactly the same as under cap & trade case A. However, this is not the case. The fuel switch CO_2-prices decrease compared with cap & trade case A, they are the same as under cap & trade case C.

With auctioning competition is back in the market. Electricity producers can compete for market share by accepting a lower gross margin. In this example, gross margins of € 7/MWh for gas-fired electricity and € 15/MWh for coal-fired electricity are assumed. The fuel switch price is lower because gas-fired plants can produce at a lower margin than coal-fired plants:

Fuel	Technology	Efficiency	Competitive gross margins €/MWh	Fuel + CO2 cost + gross margin Real switch €/MWh	CO_2-price (EURO/ton)												
Auctioning					**5,2**	**7,7**	**12,0**	15,0	19,6	**23,6**	**25,6**	27,5	30,4	**34,6**	40,0	45,1	58,0
					I	**II**	**III**				**IV**			**V**			
					Market prices with competitive margins and lower windfall profits												
Gas	**CCGT average**	**49%**	**7,0**	36,4	**38,5**	**39,6**	**41,3**	42,6	44,5	46,1	46,9	47,7	48,9	50,6	52,9	55,0	60,3
	Conventional	40%	**7,0**	43,0	45,6	46,9	49,0	50,6	52,9	54,9	**55,9**	56,9	58,3	**60,5**	63,2	65,8	72,3
Coal	Modern	40%	**15,0**	31,2	35,6	37,7	**41,3**	43,9	47,8	51,2	52,9	54,5	56,9	**60,5**	65,0	69,4	80,3
	Average	**37%**	**15,0**	32,5	37,3	**39,6**	43,5	46,2	50,4	54,1	**55,9**	57,7	60,3	64,2	69,1	73,8	85,6
	Old	35%	**15,0**	33,5	**38,5**	41,0	45,1	48,0	52,5	56,4	58,3	60,1	62,9	67,0	72,2	77,1	89,6

Note: the fuel-switch prices are in the same order of magnitude if gross margins of € 10/MWh for gas-fired plants and € 20/MWh for coal-fired plants are applied.

This leads to the following comparison between auctioning and cap & trade:

Fuel	Technology	Efficiency		Switch	I	II	III	IV	V
Auctioning versus cap & trade				CO_2-switchprice (EURO/ton) cap & trade	19,6	23,6	30,4	45,1	58,0
				CO_2-switchprice (EURO/ton) auctioning	5,2	7,7	12,0	25,6	34,6
			Competitive gross margins €/MWh	Market price auctioning minus market price under cap & trade €/MWh					
Gas	**CCGT average**	**49%**	**7,0**		1,1	0,4	-0,6		
	Conventional	40%	**7,0**					-2,9	-4,8
Coal	Modern	40%	**15,0**				-0,6		-4,8
	Average	**37%**	**15,0**			0,4		-2,9	
	Old	35%	**15,0**		1,1				

Until the second (important) switch, market prices are higher than under cap & trade case A. As from the third switch auctioning results in somewhat lower electricity prices, they are the same as the more likely model of cap & trade case C.

VII.2 Auctioning no panacea for solving windfall profits in the EU

Windfall profits have been eliminated only to some extent. The reasons are:

- Nuclear and renewables (still mainly large scale hydropower) have a market share of about 45% in the EU-25. This means that windfall profits still exist for 45%.
- After an auction the CO_2-price can easily increase, for example if the price differential between coal and gas increases. Then windfall profits are generated for the increase, this time again for all electricity producers. The only remedy would be daily auctions well orchestrated in all Member States and based upon an annual load curve of the electricity production of the entire EU-25. This would cause high transaction costs and still important deviations because the realised annual load curve will certainly deviate from the forecasted projections.
- If after auction CO_2-prices decrease, electricity producers are faced with sunk costs, which they hardly can recuperate in the market. This situation is also unacceptable.

In the discussion of auctioning as a solution to the windfall profits, these shortcomings have not been addressed. After careful analysis, auctioning appears not to be the panacea for solving the issue of windfall profits in the EU.

VII.3 Auctioning does not solve the issue of higher electricity prices

Under auctioning, the burden of higher electricity prices for the users is still present. The higher market prices by auctioning if compared to the situation without emissions trading are shown below:

Fuel	Technology	Efficiency	Competitive gross margins €/MWh	I	II	III	IV	V
Auctioning versus without emissions trading								
CO_2-switchprice (EURO/ton) cap & trade				19,6	23,6	30,4	45,1	58,0
CO_2-switchprice (EURO/ton) auctioning				5,2	7,7	12,0	25,6	34,6
Market price auctioning minus market price without emissions trading €/MWh								
Gas	**CCGT average**	**49%**	**7,0**	**2,1**	**3,2**	**4,9**		
	Conventional	40%	**7,0**				**12,9**	**17,5**
Coal	Modern	40%	**15,0**			**10,1**		**29,3**
	Average	**37%**	**15,0**		**7,1**		**23,4**	
	Old	35%	**15,0**	**5,0**				

From the perspective of the competitiveness of industrial users of electricity auctioning is no way near a solution to the current problems encountered under cap & trade.

VII.4 Auctioning at a higher price differential between coal & gas

The results under auctioning are also presented at a higher price differential between coal and gas:

Auctioning High price differential coal - gas

Full delivered fuel prices	€/GJ	
Coal	1,8	38%
Gas	4,7	

Merit order: 1 2 3 4 5 — Cheapest … Most expensive

SRMC = Short Run Marginal Cost

Fuel	Technology	Efficiency	Benchmark ton CO2/MWh auctioning	Real	Fuel cost €/MWh	5 SRMC	7,5 SRMC	14,5 SRMC	17,9 SRMC	23,8 SRMC	**28,9** SRMC	**33,9** SRMC	41,0 SRMC	**42,3** SRMC	50 SRMC	53,1 SRMC	**60,5** SRMC	**76,5** SRMC
										Apparent switch:	I	II		III			IV	V
Gas	**CCGT average**	**49%**	**0,0**	**0,41**	34,5	36,6	37,6	40,5	41,9	44,3	**46,4**	**48,5**	51,4	**51,9**	**55,1**	56,4	59,5	66,1
	Conventional	40%	**0,0**	**0,50**	42,3	44,8	46,1	49,6	51,4	54,3	56,9	59,4	63,0	63,6	67,5	69,1	**72,8**	**80,9**
Coal	Modern	40%	**0,0**	**0,85**	16,2	20,4	22,5	28,4	31,4	36,3	40,6	44,9	50,9	**51,9**	58,5	61,1	67,4	**80,9**
	Average	**37%**	**0,0**	**0,91**	17,5	22,1	24,4	30,7	33,9	39,3	43,9	**48,5**	55,0	56,2	63,2	66,0	**72,8**	87,5
	Old	35%	**0,0**	**0,97**	18,5	23,3	25,8	32,5	35,9	41,5	**46,4**	51,3	58,1	59,4	66,9	69,8	77,0	92,5

Fuel	Technology	Efficiency	CO2-cost in €/MWh (SRMC - fuel cost):												
Gas	**CCGT average**	**49%**	2,1	3,1	6,0	7,4	9,8	**11,9**	**14,0**	16,9	**17,4**	20,6	21,9	24,9	31,5
	Conventional	40%	2,5	3,8	7,3	9,1	12,0	14,6	17,1	20,7	21,3	25,2	26,8	**30,5**	**38,6**
Coal	Modern	40%	4,2	6,3	12,2	15,2	20,1	24,4	28,7	34,7	**35,7**	**42,3**	44,9	51,2	**64,7**
	Average	**37%**	4,6	6,9	13,2	16,4	21,8	26,4	**31,0**	37,5	38,6	45,7	48,5	**55,3**	70,0
	Old	35%	4,8	7,3	14,0	17,4	23,0	**27,9**	32,7	39,6	40,9	48,3	51,3	58,5	74,0

The lower fuel switch prices are presented below:

Fuel	Technology	Efficiency	Competitive gross margins €/MWh	Fuel + CO2 cost + gross margin €/MWh	5,0	7,5	**14,5**	**17,9**	**23,8**	28,9	33,9	**41,0**	42,3	50	**53,1**	60,5	76,5
Auctioning					Real switch		I	II	III			IV			V		
					Market prices with competitive margins and lower windfall profits												
Gas	**CCGT average**	**49%**	**7,0**	41,5	43,6	44,6	**47,5**	**48,9**	**51,3**	53,4	55,5	58,4	58,9	62,1	63,4	66,5	73,1
	Conventional	40%	**7,0**	49,3	51,8	53,1	56,6	58,4	61,3	63,9	66,4	**70,0**	70,6	74,5	**76,1**	79,8	87,9
Coal	Modern	40%	**15,0**	31,2	35,4	37,5	43,4	46,4	**51,3**	55,6	59,9	65,9	66,9	73,5	**76,1**	82,4	95,9
	Average	**37%**	**15,0**	32,5	37,1	39,4	45,7	**48,9**	54,3	58,9	63,5	**70,0**	71,2	78,2	81,0	87,8	102,5
	Old	35%	**15,0**	33,5	38,3	40,8	**47,5**	50,9	56,5	61,4	66,3	73,1	74,4	81,9	84,8	92,0	107,5

This leads to the following comparison between auctioning and cap & trade:

Fuel	Technology	Efficiency		Switch	I	II	III	IV	V
Auctioning versus cap & trade				CO_2-switchprice (EURO/ton) cap & trade	22,5	28,9	33,9	60,5	76,5
				CO_2-switchprice (EURO/ton) auctioning	14,5	17,9	23,8	33,9	53,1
			Competitive gross margins €/MWh	Market price auctioning minus market price under cap & trade €/MWh					
Gas	CCGT average	49%	7,0		1,1	0,4	-0,6		
	Conventional	40%	7,0					-2,9	-4,8
Coal	Modern	40%	15,0				-0,6		-4,8
	Average	37%	15,0			0,4		-2,9	
	Old	35%	15,0		1,1				

From this analysis it can be concluded that market prices are virtually not lowered if compared to cap & trade. Most likely they are the same (cap & trade case C).

If compared to the situation without emissions trading electricity prices still increase significantly to unacceptable levels for the global competitiveness of EU producers:

Fuel	Technology	Efficiency		Switch	I	II	III	IV	V
Auctioning versus without emissions trading				CO_2-switchprice (EURO/ton) cap & trade	22,5	28,9	33,9	60,5	76,5
				CO_2-switchprice (EURO/ton) auctioning	14,5	17,9	23,8	33,9	53,1
			Competitive gross margins €/MWh	Market price auctioning minus market price without emissions trading €/MWh					
Gas	CCGT average	49%	7,0		6,0	7,4	9,8		
	Conventional	40%	7,0					20,7	26,8
Coal	Modern	40%	15,0				20,1		44,9
	Average	37%	15,0			16,4		37,5	
	Old	35%	15,0		14,0				

VII.5 The functioning of auctioning for electricity in detail

As with cap & trade, it is interesting to study in detail how auctioning works out in the simplified model of the same two power plants:

Auctioning

Higher price differential coal - gas

Full delivered fuel prices	€/GJ	
Coal	1,8	38%
Gas	4,7	

Cheapest More expensive

MPCM = Market Price at Competitive Margin

PSR ton CO2 per MWh	Technology	Competitive gross margins €/MWh	Efficiency	ton CO_2 per MWh	Fuel cost €/MWh	CO_2-price (EURO/ton) 0	5	10	17,9 Before switch	17,9 After switch	20	25	30	33,9	40	45	50
						MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM
0,00	CCGT average	7,0	49%	0,41	34,5	41,5	43,6	45,7	48,9	48,9	49,8	51,8	53,9	55,5	58,0	60,1	62,1
0,00	Coal average	15,0	37%	0,91	17,5	32,5	37,1	41,7	48,9	48,9	50,8	55,4	60,0	63,5	69,1	73,7	78,2

		0	5	10	17,9	17,9	20	25	30	33,9	40	45	50
Market price at high demand (€/MWh)	50%	41,5	43,6	45,7	48,9	48,9	50,8	55,4	60,0	63,5	69,1	73,7	78,2
Market price at low demand (€/MWh)	50%	32,5	37,1	41,7	48,9	48,9	50,8	55,4	60,0	63,5	69,1	73,7	78,2
Gas-fired power plant	MWe:	100	100	100	100	122	122	122	122	122	122	122	122
Emission (kton CO2/annum) assume 8000 hrs/year		330	330	330	330	403	403	403	403	403	403	403	403
Allowances = realised production x PSR (kton CO2/annum)		0	0	0	0	0	0	0	0	0	0	0	0
Shortage of allowances (kton CO2/year)		330	330	330	330	403	403	403	403	403	403	403	403
Cost of allowances (EURO mln/annum)		0	1,6	3,3	5,9	7,2	8,1	10,1	12,1	13,7	16,1	18,1	20,2
Assume historical margin (EURO/MWh)		7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0
Historical margin without switch (EURO mln/annum)		5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6
Margin after cost allowances (EURO/MWh)		7,0	7,0	7,0	7,0	7,0	8,0	10,5	13,1	15,0	18,1	20,6	23,1
Margin after cost allowances (EURO mln/annum)		5,6	5,6	5,6	5,6	6,8	7,9	10,3	12,8	14,7	17,7	20,1	22,6
Windfall margin (EURO/MWh)		0	0,0	0,0	0,0	0,0	1,0	3,5	6,1	8,0	11,1	13,6	16,1
Coal-fired power plant	MWe:	200	200	200	200	178	178	178	178	178	178	178	178
Emission (kton CO2/annum) assume 8000 hrs/year		1463	1463	1463	1463	1300	1300	1300	1300	1300	1300	1300	1300
Allowances = realised production x PSR (kton CO2/annum)		0	0	0	0	0	0	0	0	0	0	0	0
Shortage of allowances (kton CO2/year)		1463	1463	1463	1463	1300	1300	1300	1300	1300	1300	1300	1300
Cost of allowances (EURO mln/annum)		0	7,3	14,6	26,3	23,3	26,0	32,5	39,0	44,0	52,0	58,5	65,0
Assume historical margins depending on market place		Gross margin gas-fired:				7,0	Gross margin coal-fired when marginal:						15,0
Indication Netherlands: 50% 50%	Gas / coal	Gross margin coal-fired when gas-fired is marginal:											24,0
Average historical margin coal-fired (EURO/MWh)		19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5
Historical margin without switch (EURO mln/annum)		31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2
Margin after cost allowances (EURO/MWh)		19,5	18,3	17,0	15,0	15,0	15,0	15,0	15,0	15,0	15,0	15,0	15,0
Margin after cost allowances (EURO mln/annum)		31,2	29,2	27,2	24,0	21,3	21,3	21,3	21,3	21,3	21,3	21,3	21,3
Windfall margin (EURO/MWh)		0	-1,3	-2,5	-4,5	-4,5	-4,5	-4,5	-4,5	-4,5	-4,5	-4,5	-4,5
Totals for the two power plants					Before switch	After switch							
Margin after cost allowances (EURO mln/annum)		36,8	34,8	32,8	29,6	28,2	29,2	31,6	34,1	36,0	39,0	41,5	43,9
Historical margin without switch (EURO mln/annum)		36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8
Total fuel cost (EURO mln/annum)		55,6	55,6	55,6	55,6	58,7	58,7	58,7	58,7	58,7	58,7	58,7	58,7
Cost of allowances (EURO mln/annum)		0	9,0	17,9	32,2	30,6	34,1	42,6	51,1	57,7	68,1	76,7	85,2
Windfall profits (EURO mln/annum)		0	-2,0	-4,0	-7,2	-8,6	-7,6	-5,2	-2,7	-0,8	2,2	4,7	7,1
Windfall profits (%)		0%	-5%	-11%	-20%	-23%	-21%	-14%	-7%	-2%	6%	13%	19%
Windfall profit (€/MWh)		0	-0,8	-1,7	-3,0	-3,6	-3,2	-2,2	-1,1	-0,3	0,9	1,9	3,0
Average price: margin + cost of fuel + allowances (€/MWh)		38,5	41,4	44,3	48,9	48,9	50,8	55,4	60,0	63,5	69,1	73,7	78,2
Higher price of electricity by emissions trading (€/MWh)		0	2,9	5,8	10,4	10,4	12,3	16,9	21,4	25,0	30,6	35,1	39,7
Higher fuel cost by emissions trading (€/MWh)		0	0	0	0,0	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1,3
Higher cost of the allowances by Emissions trading (€/MWh)		0	3,7	7,5	13,4	12,7	14,2	17,7	21,3	24,0	28,4	31,9	35,5
Average market demand (MWe)		300	300	300	300	300	300	300	300	300	300	300	300
Total cap of historical emission (kton CO2/annum)	95%	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703
Total emission (kton CO2/annum)		1793	1793	1793	1793	1703	1703	1703	1703	1703	1703	1703	1703
Total shortage (kton CO2/annum)		90	90	90	90	0	0	0	0	0	0	0	0

Observations if compared to cap & trade:

- The break-even fuel switch is achieved at € 17.9/ton CO_2, which is the same as for cap & trade in case B. Also the break-even electricity price is exactly the same as in cap & trade case B, € 48.9/MWh, and almost the same as in case A.
- Until the fuel switch level, the gross margin of the gas-fired plant is the same as the historical gross margin. Competition is back in the market.
- The “secondary windfall profit” of the coal-fired plant when the gas-fired plant is more expensive – during periods of high demand – slowly disappears and become zero at the level of fuel switch. At this level the gross margin is equal to the normal historical gross margin. Again, competition is back in the market and assumed in this model.
- If the market needs other fuel switches as well – this gas-fired plant runs then at maximum capacity – the same “secondary windfall profits” emerge for the gas-fired power plant at higher CO_2-prices. This is a normal result of market functioning.
- The higher electricity price is fully based on the cost of allowances - € 10.4/MWh as in case B – but now the windfall profit has become negative (-23% after fuel switch).

However, the coal-fired plant will not be prepared to participate in the fuel switch because their total gross margin decreases. Therefore the model is extended with an extra margin on the electricity price (see gold bar at the head of the table):

Auctioning

Higher price differential coal - gas

Full delivered fuel prices	€/GJ	
Coal	1,8	38%
Gas	4,7	

Cheapest More expensive

MPCM = Market Price at Competitive Margin

PSR		Competitive				CO_2-price (EURO/ton)				A	1,9	3,6	B	Extra margins			
ton CO2		gross			Fuel cost	0	5	10	17,9	17,9	17,9	17,9	25	33,9	40	45	50
per MWh		margins		ton CO_2	€/MWh			Before switch		After switch							
	Technology	€/MWh	Efficiency	per MWh		MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM
0,00	CCGT average	7,0	49%	0,41	34,5	41,5	43,6	45,7	48,9	48,9	50,8	52,5	53,7	57,4	59,9	62,0	64,0
0,00	Coal average	15,0	37%	0,91	17,5	32,5	37,1	41,7	48,9	48,9	50,8	52,5	57,3	65,4	71,0	75,6	80,1
Market price at high demand (€/MWh)					50%	41,5	43,6	45,7	48,9	48,9	50,8	52,5	57,3	65,4	71,0	75,6	80,1
Market price at low demand (€/MWh)					50%	32,5	37,1	41,7	48,9	48,9	50,8	52,5	57,3	65,4	71,0	75,6	80,1
Gas-fired power plant					MWe:	100	100	100	100	122	122	122	122	122	122	122	122
Emission (kton CO2/annum) assume 8000 hrs/year						330	330	330	330	403	403	403	403	403	403	403	403
Allowances = realised production x PSR (kton CO2/annum)						0	0	0	0	0	0	0	0	0	0	0	0
Shortage of allowances (kton CO2/year)						330	330	330	330	403	403	403	403	403	403	403	403
Cost of allowances (EURO mln/annum)						0	1,6	3,3	5,9	7,2	7,2	7,2	10,1	13,7	16,1	18,1	20,2
Assume historical margin (EURO/MWh)						7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0
Historical margin without switch (EURO mln/annum)						5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6
Margin after cost allowances (EURO/MWh)						7,0	7,0	7,0	7,0	7,0	8,9	10,6	12,4	16,9	20,0	22,5	25,0
Margin after cost allowances (EURO mln/annum)						5,6	5,6	5,6	5,6	6,8	8,7	10,4	12,2	16,5	19,5	22,0	24,4
Windfall margin (EURO/MWh)						0	0,0	0,0	0,0	0,0	1,9	3,6	5,4	9,9	13,0	15,5	18,0
Coal-fired power plant					MWe:	200	200	200	200	178	178	178	178	178	178	178	178
Emission (kton CO2/annum) assume 8000 hrs/year						1463	1463	1463	1463	1300	1300	1300	1300	1300	1300	1300	1300
Allowances = realised production x PSR (kton CO2/annum)						0	0	0	0	0	0	0	0	0	0	0	0
Shortage of allowances (kton CO2/year)						1463	1463	1463	1463	1300	1300	1300	1300	1300	1300	1300	1300
Cost of allowances (EURO mln/annum)						0	7,3	14,6	26,3	23,3	23,3	23,3	32,5	44,0	52,0	58,5	65,0
Assume historical margins depending on market place						Gross margin gas-fired:				7,0	Gross margin coal-fired when marginal:						15,0
Indication Netherlands:			50%	50%	Gas / coal	Gross margin coal-fired when gas-fired is marginal:											24,0
Average historical margin coal-fired (EURO/MWh)						19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5
Historical margin without switch (EURO mln/annum)						31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2
Margin after cost allowances (EURO/MWh)						19,5	18,3	17,0	15,0	15,0	16,9	18,6	16,9	16,9	16,9	16,9	16,9
Margin after cost allowances (EURO mln/annum)						31,2	29,2	27,2	24,0	21,3	24,0	26,4	24,0	24,0	24,0	24,0	24,0
Windfall margin (EURO/MWh)						0	-1,3	-2,5	-4,5	-4,5	-2,6	-0,9	-2,6	-2,6	-2,6	-2,6	-2,6
Totals for the two power plants								Before switch		After switch							
Margin after cost allowances (EURO mln/annum)						36,8	34,8	32,8	29,6	28,2	32,7	36,8	36,2	40,5	43,5	46,0	48,4
Historical margin without switch (EURO mln/annum)						36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8
Total fuel cost (EURO mln/annum)						55,6	55,6	55,6	55,6	58,7	58,7	58,7	58,7	58,7	58,7	58,7	58,7
Cost of allowances (EURO mln/annum)						0	9,0	17,9	32,2	30,6	30,6	30,6	42,6	57,7	68,1	76,7	85,2
Windfall profits (EURO mln/annum)						0	-2,0	-4,0	-7,2	-8,6	-4,1	0,0	-0,7	3,7	6,7	9,2	11,6
Windfall profits (%)						0%	-5%	-11%	-20%	-23%	-11%	0%	-2%	10%	18%	25%	32%
Windfall profit (€/MWh)						0	-0,8	-1,7	-3,0	-3,6	-1,7	0,0	-0,3	1,5	2,8	3,8	4,8
Average price: margin + cost of fuel + allowances (€/MWh)						38,5	41,4	44,3	48,9	48,9	50,8	52,5	57,3	65,4	71,0	75,6	80,1
Higher price of electricity by emissions trading (€/MWh)						0	2,9	5,8	10,4	10,4	12,3	14,0	18,7	26,8	32,5	37,0	41,6
Higher fuel cost by emissions trading (€/MWh)						0	0	0	0,0	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1,3
Higher cost of the allowances by Emissions trading (€/MWh)						0	3,7	7,5	13,4	12,7	12,7	12,7	17,7	24,0	28,4	31,9	35,5
Average market demand (MWe)						300	300	300	300	300	300	300	300	300	300	300	300
Total cap of historical emission (kton CO2/annum)					95%	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703
Total emission (kton CO2/annum)						1793	1793	1793	1793	1703	1703	1703	1703	1703	1703	1703	1703
Total shortage (kton CO2/annum)						90	90	90	90	0	0	0	0	0	0	0	0

Observations of the extended auctioning model:

- The compensation for the loss of margin of the coal-fired power plant after fuel switch is again found in a slight increase of the electricity price, in this example again € 1.9/MWh. It is remarkable that windfall profits are then still negative (-11%).
- At an extra margin of € 3.6/MWh windfall profits have become zero and the both plants have a higher total gross margin than before fuel switch.
- In the table above, the extra margin of € 1.9/MWh has been applied for the situations at higher CO_2-prices.
- What will actually happen in the market is determined by competition, the extra margin of € 1.9/MWh is expected as a minimum.

VII.6 Conclusions auctioning

Auctioning shows the following pros:

- Full agreement with the objective function:
  - Existing and new coal and lignite power plants need to buy allowances for their emissions, which means that lower emissions per unit of product are favoured; this is like receiving the correct amount of allowances
  - Combined Heat & Power is structurally stimulated
  - Auctioning stimulates zero emission power plants in all Member States
- Some agreement with the principle of equal treatment, the windfall profits for the electricity sector are lowered to some extent.
- The level playing field is not disturbed anymore as similar power plants are treated the same in different Member States.
- The enhancement frozen market shares is eliminated.
- Auctioning complies with the polluter-pays principle.

What remains are major cons:

- The still high electricity prices are detrimental to the worldwide level playing field; they do not meet the requirement of the least possible diminution of economic development and employment.
- Windfall profits are eliminated partly, this cure works only poorly. This is disadvantageous when auctioning is not applied globally.
- Auctioning can lead to (unacceptable) sunk costs for electricity producers.
- Full auctioning is only allowed to a maximum of 5% in the 1st trading period and 10% in the 2nd trading period. This may be extended to about 20% when applied to electricity producers solely, which is still far insufficient and it provides no remedy for the fundamental shortcomings of cap & trade for the other sectors.

In sum, auctioning is a good method, but only if applied globally.

VIII Auctioning with recycling of revenues

Revenues of auctions can be recycled to the users or to the producers of electricity. Therefore both options are assessed.

VIII.1 Auctioning with recycling of revenues to electricity users

This option seems attractive with the aim to compensate users of electricity for the increased electricity prices.

Furthermore, auctioning would provide a clear signal to the carbon constraint and hence stimulation for CHP and zero emission power plants.

However, from the previous analysis it is clear that this option falls short to compensate electricity users as well as to comply with the requirements of the Directive:

- Revenues from auctioning are much lower – about 45% - than the revenues (still leading to significant windfall profits) of electricity produces due to the significant share of nuclear and renewables in the EU-25.
- If CO_2-prices rise after an auction, this shortage of revenues further increases.
- If CO_2-prices decrease after an auction, electricity producers are faced with unacceptable sunk costs.
- The Directive forbids auctioning without recycling to the producers because only 5% auctioning in the 1st trading period and 10% auctioning in the 2nd trading period is allowed. If applied to the electricity sector alone the percentages of auctioning could be increased to about 10% and 20% respectively.

Auctioning with recycle of revenues could only be a short-term solution. Otherwise there would be a “hole” in the system: companies would undertake investments to replace natural gas for heating by electricity heating or steam to drive steam turbines with electric motors.

In conclusion, auctioning with recycle of revenues to the users of electricity is not a feasible structural solution for the problem of windfall profits and still causes a serious deterioration of competitiveness of industrial electricity users.

VIII.2 Auctioning with recycling of revenues to electricity producers

This option may provide a clear signal to the carbon constraint and hence stimulation for CHP and zero emission power plants. It is then crucial to determine which options for recycling of the revenues should be best applied. Thinkable options are:

- Recycling as a lump sum, calculated by the share of the realised emissions by a producer of the total emissions by electricity plants in the preceding year. But this is dismissed because of the conflict with the objective function. This would be cap & trade with historical grandfathering, the realised emission of the preceding year.
- Recycling as lump sum, calculated by the share of realised production of the total production by fossil-fuelled electricity of the preceding year. Now there is a reward for cleaner electricity. But because of the lump sum the system still acts as cap & trade. Any fuel switch can only take place if the electricity price corresponds with the fuel costs + opportunity-costs. Thus the windfall profits and the higher prices for electricity are not eliminated.
- Therefore it is further assumed that the recycle is done for an equal amount of money per MWh of fossil-fuelled electricity actually produced (ex-ante allowances, ex-post recycling of revenues).

The option with recycling per MWh produced may be within the requirements of the Directive. Although auctioning is applied fully, the electricity producers are also fully compensated in theory.

This leads to the following price effects:

Assume auction with recycling of revenues to producers

				Full delivered fuel prices €/GJ		
Assume CO2-price of the auction	EURO/ton	7,7				
Anticipated fossil-fuelled production	TWh	1760				
Anticipated emission	Mton	1056		Coal	1,8	45%
Revenu auction	EURO mln	8146		Gas	4,0	
Recycling to producers	EURO.MWh	4,6				

Fuel	Technology	Efficiency	Competitive gross margins €/MWh	Switch	I	II	III	IV	V
				CO_2-switchprice (EURO/ton) cap & trade	19,6	23,6	30,4	45,1	58,0
				CO_2-switchprice (EURO/ton) auctioning	5,2	7,7	12,0	25,6	34,6
				Market price auctioning with revenue recycling minus market price without emissions trading					
Gas	CCGT average	49%	7,0	€/MWh:	-2,5	-1,5	0,3		
	Conventional	40%	7,0					8,3	12,8
Coal	Modern	40%	15,0				5,5		24,6
	Average	37%	15,0			2,4		18,8	
	Old	35%	15,0		0,4				

In case the forecast turns out to be about correct, the price increase of electricity is modest at the forecasted switch number II and reflects about the real cost of fuel switch.

But in case the shortage of the market for CO_2-allowances is higher than expected beforehand, for example if less hydropower is available or if the economic growth of other sectors is higher, then higher fuel switches are necessary (for example switch III and IV). This means that there will again be windfall profits and higher prices for electricity users.

Apart from a change of the shortage of allowances in the market, the CO_2-price can easily increase after an auction, for example if the price differential between coal and gas increases. Also then windfall profits for all electricity producers and much higher prices for electricity users occur again.

The problem of changes of the price of CO_2 can be remedied only if the auctioning frequency is increased according to the volatility of the market. This means at least monthly but probably weekly or even daily auctions and the amounts of allowances need to be based upon the projected load curve of the entire EU-25.

This method works only satisfactory if producers get a good indication of the basis for the recycle of the revenues. After each auction the expected amount of money per MWh should be indicated. If producers apply more conservative estimates of the recycle per MWh, the electricity price decrease will be lower as it should be ex-post.

VIII.3 Conclusions auctioning with recycle of revenues

In conclusion, auctioning with recycling of revenues to electricity producers seems to be the best option identified so far. An advantage is that there is no ex-post control on the amount of allowances but there is ex-post control on the recycle per unit of production.

Disadvantages are the high transaction costs and deviations from the concept when markets are highly volatile and when the realised electricity production deviates from the ex-ante projections.

Furthermore, auction with recycle of revenues is no real robust solution, as it is also a complicated and expensive method for other products falling under the scheme.

IX Fuel-specific PSRs (Performance Standard Rates)

It is often assumed that fuel-specific PSRs might be an acceptable solution. Fuel-specific PSRs might be an acceptable solution for Member States with a high proportion of coal and lignite, e.g. Germany.

Fuel-specific PSRs without abandoning frozen caps for individual installations would not change the fundamental objections of cap & trade. Windfall profits would be the same.

Therefore, the possibility of fuel-specific PSRs is tested with ex-post control of the amount of electricity produced.

IX.1 Fuel-specific PSRs at a higher price differential between coal and gas

The effect on electricity and CO_2-prices is calculated for this option:

Fuel-specific PSRs
High price
differential
coal - gas

Full delivered fuel prices	€/GJ	
Coal	1,8	38%
Gas	4,7	

Merit order

1	2	3	4	5
Cheapest			Most expensive	

SRMC = Short Run Marginal Cost

Fuel	Technology	Efficiency	PSR ton CO2/MWh	Real	Fuel cost €/MWh	CO_2-price (EURO/ton) 10 SRMC	30 SRMC	114 SRMC Apparent switch:	229 SRMC I	506 SRMC	954 SRMC II	No feasible solutions -361 SRMC III	-203,5 SRMC	-331 SRMC IV	-224 SRMC	-182 SRMC V	-126 SRMC
Gas	**CCGT average**	**49%**	**0,43**	**0,41**	34,5	34,4	34,0	32,5	**30,5**	25,5	**17,5**	**41,0**	38,2	40,4	38,5	37,8	36,8
	Conventional	40%	**0,43**	**0,50**	42,3	43,0	44,5	50,9	59,4	80,2	113,8	15,3	27,1	**17,5**	25,5	**28,7**	32,9
Coal	Modern	40%	**0,91**	**0,85**	16,2	15,5	14,1	8,4	0,5	-18,5	-49,3	**41,0**	30,2	38,9	31,6	**28,7**	24,9
	Average	**37%**	**0,91**	**0,91**	17,5	17,5	17,5	17,5	17,5	17,5	**17,5**	17,5	17,5	**17,5**	17,5	17,5	17,5
	Old	35%	**0,91**	**0,97**	18,5	19,0	20,1	24,5	**30,5**	44,9	68,4	-0,4	7,9	1,2	6,8	9,0	11,9

Fuel	Technology	Efficiency				CO2-cost in €/MWh (SRMC - fuel cost):											
Gas	**CCGT average**	**49%**				-0,2	-0,5	-2,0	**-4,1**	-9,0	**-17,0**	6,4	3,6	5,9	4,0	3,2	2,2
	Conventional	40%				0,7	2,2	8,6	17,1	37,9	71,5	-27,0	-15,2	-24,8	-16,8	-13,6	-9,4
			PSR method														
Coal	Modern	40%				-0,7	-2,1	-7,8	-15,7	-34,7	-65,5	24,8	14,0	22,7	15,4	12,5	8,7
	Average	**37%**				0,0	0,0	0,0	0,0	0,0	**0,0**	0,0	0,0	0,0	0,0	0,0	0,0
	Old	35%				0,5	1,6	6,0	**11,9**	26,4	49,9	-18,9	-10,6	-17,3	-11,7	-9,5	-6,6

The effect on market prices for electricity seems modest <u>at</u> the fuel switch prices:

Fuel	Technology	Efficiency	Competitive gross margins €/MWh	Fuel + CO2 cost + gross margin €/MWh	CO_2-price (EURO/ton) 10,0	30,0 Real switch	114 I	229	506 II	954	No feasible slutions -361	-203 III	-331	-224 IV	-182	-126 V
Fuel-specific PSRs					Market prices with competitive margins											
Gas	**CCGT average**	**49%**	**7,0**	41,5	41,4	41,0	**39,5**	37,5	**32,5**	24,5	48,0	**45,2**	47,4	45,5	44,8	43,8
	Conventional	40%	**7,0**	49,3	50,0	51,5	57,9	66,4	87,2	120,8	22,3	34,1	24,5	**32,5**	35,7	**39,9**
Coal	Modern	40%	**15,0**	31,2	30,5	29,1	23,4	15,5	-3,5	-34,3	56,0	**45,2**	53,9	46,6	43,7	**39,9**
	Average	**37%**	**15,0**	32,5	32,5	32,5	32,5	32,5	**32,5**	32,5	32,5	32,5	32,5	**32,5**	32,5	32,5
	Old	35%	**15,0**	33,5	34,0	35,1	**39,5**	45,5	59,9	83,4	14,6	22,9	16,2	21,8	24,0	26,9

Under fuel-specific PSRs with ex-post control, CO_2-prices would rise to unprecedented levels. The important second switch would take place at € 506/ton CO_2 in this example. The reason is that fuel-specific PSRs show a lack of carbon differentiation while the objective function of the carbon constraint is still in place.

The consequence of fuel specificity is that gas-fired plants can never substitute coal and lignite plants better than the PSR and that worse than PSR gas-fired plants can never substitute any coal and lignite power plants (see in table under “no feasible solutions”). The fuel switch potential is decreased by about 50%.

In addition to chaotic CO_2-prices, fuel-specific PSRs deliver also chaotic power prices:

Fuel	Technology	Efficiency	Competitive gross margins €/MWh	Switch	I	II	III	IV	V
PSR fuel specific versus cap & trade				CO_2-switchprice (EURO/ton) cap & trade	28,9	33,9			
				CO_2-switchprice (EURO/ton) PSR fuel specific	114	506	No feasible solutions These fuel switches are not possible		
				Market price PSR minus market price under cap & trade €/MWh					
Gas	**CCGT average**	**49%**	**7,0**		-6,9	-16,0			
	Conventional	40%	7,0		1,0	27,8			
Coal	Modern	40%	15,0		-17,3	-48,3			
	Average	**37%**	15,0		-11,4	-16,0			
	Old	35%	15,0		-6,9	8,7			

Fuel	Technology	Efficiency	Competitive gross margins €/MWh	Switch	I	II	III	IV	V
PSR fuel specific versus without emissions trading				CO_2-switchprice (EURO/ton) cap & trade	28,9	33,9			
				CO_2-switchprice (EURO/ton) PSR fuel specific	114,4	506	No feasible solutions These fuel switches are not possible		
				Market price PSR minus market price without emissions trading €/MWh					
Gas	**CCGT average**	**49%**	**7,0**		-2,0	-9,0			
	Conventional	40%	7,0		8,6	37,9			
Coal	Modern	40%	15,0		-7,8	-34,7			
	Average	**37%**	15,0		0,0	0,0			
	Old	35%	15,0		6,0	26,4			

At the important 2nd fuel switch – at € 506/ton CO_2 – electricity prices when coal is marginal would fluctuate between € 34.7/MWh lower and € 26.4/MWh higher compared with the situation without emissions trading. The latter may for example happen when fuel switch takes place in the UK and less efficient coal and lignite plants are needed in Germany.

IX.2 Conclusions fuel-specific PSRs

Fuel-specific PSRs with ex-post control show the following pros:

- Sometimes lower electricity prices than under cap & trade are supportive to the worldwide level playing field.
- Some agreement with the principle of equal treatment, the electricity sector is not favoured anymore by windfall profits at a particular fuel switch price level.
- The level playing field is not disturbed anymore as same power plants get the same allocation in different Member States.
- The enhancement of frozen market shares is eliminated for plants with the same fuel.

The cons are however still in the majority and not in agreement with the aim of the Directive:

- No agreement with the objective function, efficient coal and lignite plants would be equally stimulated as efficient gas-fired power plants.
  - Existing and new coal and lignite power plants are receiving too many allowances
  - Combined Heat & Power is not stimulated structurally as under auctioning.
  - The same is true for zero emission power plants.
- The further fuel switches III, IV and V cannot occur anymore. An efficient CCGT plant can never substitute a better than average coal or lignite plant. The potential for fuel switch is lowered by about 50% when two PSRs would be applied (and even more in case an additional PSR for lignite would be adopted).
- The CO_2-prices, needed fuel-switch prices become very high. This is not acceptable in relation to a well functioning market for allowances for the other sectors.
- Electricity prices will often become much higher than under cap & trade and hence windfall profits appear again on a large scale.
- Fuel-specific PSRs do not comply with the polluter-pays principle.

X PSR (Performance Standard Rate)

The PSR method is an alternative, where the emission allowances are related to the units of product actually produced. Its effects compare with auctioning. Without however, as we shall see, the shortcomings of auctioning where the EU is going it alone. In fact, PSR is a kind of partial auctioning. One uniform standard combines the carbon constraint aimed at by the Directive while the future of coal and lignite is assured by a clear and unambiguous signal to move to zero emission power plants.

Also co-firing of biomass should be included and then stimulated for existing and new plants.

The effects on the market for CO_2 are the same as under auctioning, but now electricity prices are hardly affected. In sum, this is caused by the following key mechanism:

- Under the PSR method versus auctioning, electricity producers incur much lower costs for power plants with a carbon-efficiency worse than the PSR.

X.1 PSR at a “normal” price differential between coal & gas

First, the effect of PSR is considered at the “normal” price differential between gas and coal:

PSR (Performance Standard Rate)
"Normal" price differential
coal - gas

Full delivered fuel prices	€/GJ	
Coal	1,8	45%
Gas	4,0	

	1	2	3	4	5
Merit order					
	Cheapest			Most expensive	

SRMC = Short Run Marginal Cost

Fuel	Technology	Efficiency	PSR ton CO2/MWh	Real	Fuel cost €/MWh	CO₂-price (EURO/ton) 5,2 SRMC	7,7 SRMC	12,0 SRMC	15,0	19,6 SRMC I	23,6 SRMC II	25,6 SRMC	27,5 SRMC	30,4 SRMC III	34,6 SRMC	40,0 SRMC	45,1 SRMC IV	58,0 SRMC V
								Apparent switch:										
Gas	**CCGT average**	**49%**	**0,70**	**0,41**	29,4	27,9	27,2	25,9	25,1	**23,7**	**22,6**	22,0	21,5	**20,6**	19,4	17,9	16,4	12,7
	Conventional	40%	**0,70**	**0,50**	36,0	35,0	34,5	33,7	33,1	32,2	31,4	31,0	30,6	30,1	29,3	28,2	**27,2**	**24,7**
Coal	Modern	40%	**0,70**	**0,85**	16,2	17,0	17,3	17,9	18,4	19,1	19,7	19,9	20,2	**20,6**	21,3	22,0	22,8	**24,7**
	Average	**37%**	**0,70**	**0,91**	17,5	18,6	19,2	20,1	20,7	21,7	**22,6**	23,0	23,4	24,0	24,9	26,1	**27,2**	30,0
	Old	35%	**0,70**	**0,97**	18,5	19,9	20,6	21,7	22,5	**23,7**	24,8	25,3	25,9	26,6	27,7	29,2	30,6	34,0

Fuel	Technology	Efficiency		CO2-cost in €/MWh (SRMC - fuel cost):												
Gas	**CCGT average**	**49%**		-1,5	-2,2	-3,4	-4,3	**-5,6**	**-6,8**	-7,4	-7,9	-8,7	-10,0	-11,5	-13,0	-16,7
	Conventional	40%		-1,0	-1,5	-2,3	-2,9	-3,8	-4,6	-5,0	-5,4	-5,9	-6,7	-7,8	**-8,8**	**-11,3**
			PSR method													
Coal	Modern	40%		0,8	1,1	1,7	2,2	2,9	3,5	3,7	4,0	4,4	**5,1**	5,8	6,6	**8,5**
	Average	**37%**		1,1	1,7	2,6	3,2	4,2	**5,1**	5,5	5,9	6,5	7,4	8,6	**9,7**	12,5
	Old	35%		1,4	2,1	3,2	4,0	**5,2**	6,3	0,0	7,3	8,1	9,2	10,7	12,0	15,5

The relatively small effect of higher prices when coal-fired plants are the marginal plants is virtually offset by the lower prices when gas-fired plants are marginal.

The resulting market prices and the lower fuel switch prices are shown below:

Fuel	Technology	Efficiency	Competitive gross margins €/MWh	Fuel + CO2 cost + gross margin Real switch €/MWh	CO₂-price (EURO/ton) 5,2 I	7,7 II	12,0 III	15,0	19,6	23,6	25,6 IV	27,5	30,4	34,6 V	40,0	45,1	58,0
PSR method					Market prices with competitive margins and zero windfall profits												
Gas	**CCGT average**	**49%**	**7,0**	36,4	**34,9**	**34,2**	**32,9**	32,1	30,7	29,6	29,0	28,5	27,6	26,4	24,9	23,4	19,7
	Conventional	40%	**7,0**	43,0	42,0	41,5	40,7	40,1	39,2	38,4	**38,0**	37,6	37,1	**36,3**	35,2	34,2	31,7
Coal	Modern	40%	**15,0**	31,2	32,0	32,3	**32,9**	33,4	34,1	34,7	34,9	35,2	35,6	**36,3**	37,0	37,8	39,7
	Average	**37%**	**15,0**	32,5	33,6	**34,2**	35,1	35,7	36,7	37,6	**38,0**	38,4	39,0	39,9	41,1	42,2	45,0
	Old	35%	**15,0**	33,5	**34,9**	35,6	36,7	37,5	38,7	39,8	40,3	40,9	41,6	42,7	44,2	45,6	49,0

The fuel switch prices are exactly the same as under auctioning.

But compared with cap & trade or auctioning, electricity prices are much lower under PSR (probably even lower because cap & trade case A is taken here as comparison):

Fuel	Technology	Efficiency		Switch	I	II	III	IV	V
PSR versus cap & trade				CO_2-switchprice (EURO/ton) cap & trade	19,6	23,6	30,4	45,1	58,0
				CO_2-switchprice (EURO/ton) under PSR	5,2	7,7	12,0	25,6	34,6
			Competitive gross margins €/MWh	Market price PSR minus market price under cap & trade €/MWh					
Gas	CCGT average	49%	7,0		-2,6	-5,0	-9,0		
	Conventional	40%	7,0					-20,8	-29,1
Coal	Modern	40%	15,0				-9,0		-29,1
	Average	37%	15,0			-5,0		-20,8	
	Old	35%	15,0		-2,6				

The effect of market prices under PSR compared with the situation without emissions trading is demonstrated in the following table:

Fuel	Technology	Efficiency		Switch	I	II	III	IV	V
PSR versus without emissions trading				CO_2-switchprice (EURO/ton) cap & trade	19,6	23,6	30,4	45,1	58,0
				CO_2-switchprice (EURO/ton) under PSR	5,2	7,7	12,0	25,6	34,6
			Competitive gross margins €/MWh	Market price PSR minus market price without emissions trading €/MWh					
Gas	CCGT average	49%	7,0		-1,5	-2,2	-3,4		
	Conventional	40%	7,0					-5,0	-6,7
Coal	Modern	40%	15,0				1,7		5,1
	Average	37%	15,0			1,7		5,5	
	Old	35%	15,0		1,4				

Observations PSR:

- Electricity prices, when coal-fired power plants are marginal, will rise modestly at the first three switches and somewhat more at the higher switches.
- Electricity prices, when gas-fired power plants are marginal, will decrease modestly at the first three switches and somewhat more at the higher switches.
- Both opposite effects mitigate the average price increase of electricity.

X.2 PSR at a higher price differential between coal & gas

The effect of PSR is considered also at a higher price differential between gas and coal:

PSR (Performance Standard Rate) High price differential coal - gas

Full delivered fuel prices	€/GJ	
Coal	1,8	38%
Gas	4,7	

Merit order: 1 2 3 4 5 — Cheapest … Most expensive

SRMC = Short Run Marginal Cost

Fuel	Technology	Efficiency	PSR ton CO2/MWh	Real	Fuel cost €/MWh	SRMC (5)	SRMC (7,5)	SRMC (14,5)	SRMC (17,9)	SRMC (23,8)	SRMC (28,9)	SRMC (33,9)	SRMC (41,0)	SRMC (42,3)	SRMC (50)	SRMC (53,1)	SRMC (60,5)	SRMC (76,5)
					CO₂-price (EURO/ton) → Apparent switch:						I	II		III			IV	V
Gas	CCGT average	49%	0,70	0,41	34,5	33,1	32,4	30,4	29,4	27,7	26,2	24,8	22,7	22,4	20,1	19,3	17,1	12,5
	Conventional	40%	0,70	0,50	42,3	41,3	40,8	39,5	38,8	37,7	36,7	35,7	34,3	34,1	32,5	31,9	30,5	27,4
Coal	Modern	40%	0,70	0,85	16,2	16,9	17,3	18,3	18,8	19,7	20,4	21,1	22,2	22,4	23,5	23,9	25,0	27,4
	Average	37%	0,70	0,91	17,5	18,6	19,1	20,6	21,4	22,6	23,7	24,8	26,3	26,6	28,2	28,9	30,5	33,9
	Old	35%	0,70	0,97	18,5	19,8	20,5	22,4	23,3	24,9	26,2	27,6	29,4	29,8	31,9	32,7	34,7	38,9

Fuel	Technology	Efficiency		CO2-cost in €/MWh (SRMC - fuel cost):												
Gas	CCGT average	49%		-1,4	-2,2	-4,2	-5,2	-6,9	-8,3	-9,7	-11,8	-12,2	-14,4	-15,3	-17,4	-22,0
	Conventional	40%		-1,0	-1,5	-2,8	-3,5	-4,6	-5,6	-6,6	-8,0	-8,2	-9,8	-10,4	-11,8	-14,9
			PSR method													
Coal	Modern	40%		0,7	1,1	2,1	2,6	3,5	4,2	4,9	6,0	6,2	7,3	7,7	8,8	11,2
	Average	37%		1,1	1,6	3,1	3,9	5,1	6,2	7,3	8,8	9,1	10,7	11,4	13,0	16,4
	Old	35%		1,3	2,0	3,9	4,8	6,4	7,7	9,0	10,9	11,3	13,3	14,2	16,1	20,4

This results in following market prices:

Fuel	Technology	Efficiency	Competitive gross margins €/MWh	Fuel + CO2 cost + gross margin €/MWh	CO₂-price (EURO/ton) 5,0	7,5	14,5	17,9	23,8	28,9	33,9	41,0	42,3	50	53,1	60,5	76,5
PSR method					Real switch		I	II	III			IV			V		
					Market prices with competitive margins and zero windfall profits												
Gas	**CCGT average**	**49%**	**7,0**	41,5	40,1	39,4	**37,4**	**36,4**	**34,7**	33,2	31,8	29,7	29,4	27,1	26,3	24,1	19,5
	Conventional	40%	**7,0**	49,3	48,3	47,8	46,5	45,8	44,7	43,7	42,7	**41,3**	41,1	39,5	**38,9**	37,5	34,4
Coal	Modern	40%	**15,0**	31,2	31,9	32,3	33,3	33,8	**34,7**	35,4	36,1	37,2	37,4	38,5	**38,9**	40,0	42,4
	Average	**37%**	**15,0**	32,5	33,6	34,1	35,6	**36,4**	37,6	38,7	39,8	**41,3**	41,6	43,2	43,9	45,5	48,9
	Old	35%	**15,0**	33,5	34,8	35,5	**37,4**	38,3	39,9	41,2	42,6	44,4	44,8	46,9	47,7	49,7	53,9

Compared with cap & trade market prices are much lower if governed by PSR:

Fuel	Technology	Competitive gross margins €/MWh	Switch	I	II	III	IV	V
PSR versus cap & trade			CO_2-switchprice (EURO/ton) cap & trade	28,9	33,9	42,3	60,5	76,5
			CO_2-switchprice (EURO/ton) PSR method	14,5	17,9	23,8	41,0	53,1
			Market price PSR minus market price under cap & trade €/MWh					
Gas	**CCGT average**	7,0		-9,1	-12,1	-17,3		
	Conventional	7,0					-31,5	-42,0
Coal	Modern	15,0				-17,3		-42,0
	Average	15,0			-12,1		-31,5	
	Old	15,0		-9,1				

PSR for electricity equals auctioning in terms of market functioning and the provision of unambiguous signals to stimulate efficiency improvement.

It is vital that this PSR is a uniform PSR for combined markets within the EU. Otherwise unjustified electricity flows from one Member State to another would occur.

The electricity prices under PSR compared with market prices without emissions trading are demonstrated below:

Fuel	Technology	Competitive gross margins €/MWh	Switch	I	II	III	IV	V
PSR versus without emissions trading			CO_2-switchprice (EURO/ton) cap & trade	28,9	33,9	42,3	60,5	76,5
			CO_2-switchprice (EURO/ton) PSR method	14,5	17,9	23,8	41,0	53,1
			Market price PSR minus market price without emissions trading €/MWh					
Gas	**CCGT average**	7,0		-4,2	-5,2	-6,9		
	Conventional	7,0					-8,0	-10,4
Coal	Modern	15,0				3,5		7,7
	Average	15,0			3,9		8,8	
	Old	15,0		3,9				

X.3 The importance of ex-post control

In the presented PSR approach the amount of allowances is linked to the realised amount of production. One can only sell allowances when production is more efficient than PSR. Thus the windfall profit dilemma: “do I produce to realise my margin, or not produce and still realise my margin through the sale of allowances?” does not arise. It works exactly the same as auctioning; therefore PSR is a kind of partial auctioning without the detrimental effect on global competitiveness.

Under auctioning the cost-price difference between two producers or installations is defined by the difference of the carbon efficiency. Exactly the same is true for PSR with ex-post control; take the example of electricity as presented above. The cost-price difference between installation A and installation B is:
(Eff. A – PSR) – (Eff. B – PSR) = Eff. A – PSR – Eff. B + PSR = Eff. A – Eff. B (q.e.d.)

X.4 The functioning of PSR for electricity in detail

As for auctioning, the market functioning is also studied in detail for the simplified model of the two power plants. As under auctioning, competition is back in the market:

PSR
(Performance Standard Rate)
Higher price differential
coal - gas

Full delivered fuel prices	€/GJ	
Coal	1,8	38%
Gas	4,7	

Cheapest **More expensive**
MPCM = Market Price at Competitive Margin

PSR ton CO2 per MWh	Technology	Competitive gross margins €/MWh	Efficiency	ton CO_2 per MWh	Fuel cost €/MWh	CO_2-price (EURO/ton)				A	1,9	3,6	B	Extra margins			
						0	5	10	17,9	17,9	17,9	17,9	25	33,9	40	45	50
								Before switch		After switch							
						MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM
0,71	CCGT average	7,0	49%	0,41	34,5	41,5	40,0	38,6	36,2	36,2	38,1	39,8	36,0	33,3	31,5	30,0	28,5
0,71	Coal average	15,0	37%	0,91	17,5	32,5	33,5	34,6	36,2	36,2	38,1	39,8	39,5	41,3	42,6	43,6	44,6

		0	5	10	17,9	17,9	17,9	17,9	25	33,9	40	45	50
Market price at high demand (€/MWh)	50%	41,5	40,0	38,6	36,2	36,2	38,1	39,8	39,5	41,3	42,6	43,6	44,6
Market price at low demand (€/MWh)	50%	32,5	33,5	34,6	36,2	36,2	38,1	39,8	39,5	41,3	42,6	43,6	44,6
Gas-fired power plant	MWe:	100	100	100	100	122	122	122	122	122	122	122	122
Emission (kton CO2/annum) assume 8000 hrs/year		330	330	330	330	403	403	403	403	403	403	403	403
Allowances = realised production x PSR (kton CO2/annum)		568	568	568	568	694	694	694	694	694	694	694	694
Shortage of allowances (kton CO2/year)		-238	-238	-238	-238	-291	-291	-291	-291	-291	-291	-291	-291
Cost of allowances (EURO mln/annum)		0	-1,2	-2,4	-4,3	-5,2	-5,2	-5,2	-7,3	-9,9	-11,6	-13,1	-14,6
Assume historical margin (EURO/MWh)		7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0
Historical margin without switch (EURO mln/annum)		5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6
Margin after cost allowances (EURO/MWh)		7,0	7,0	7,0	7,0	7,0	8,9	10,6	12,4	16,9	20,0	22,5	25,0
Margin after cost allowances (EURO mln/annum)		5,6	5,6	5,6	5,6	6,8	8,7	10,4	12,2	16,5	19,5	22,0	24,4
Windfall margin (EURO/MWh)		0	0,0	0,0	0,0	0,0	1,9	3,6	5,4	9,9	13,0	15,5	18,0
Coal-fired power plant	MWe:	200	200	200	200	178	178	178	178	178	178	178	178
Emission (kton CO2/annum) assume 8000 hrs/year		1463	1463	1463	1463	1300	1300	1300	1300	1300	1300	1300	1300
Allowances = realised production x PSR (kton CO2/annum)		1136	1136	1136	1136	1009	1009	1009	1009	1009	1009	1009	1009
Shortage of allowances (kton CO2/year)		328	328	328	328	291	291	291	291	291	291	291	291
Cost of allowances (EURO mln/annum)		0	1,6	3,3	5,9	5,2	5,2	5,2	7,3	9,9	11,6	13,1	14,6
Assume historical margins depending on market place		Gross margin gas-fired:				7,0	Gross margin coal-fired when marginal:						15,0
Indication Netherlands: 50% 50%	Gas / coal	Gross margin coal-fired when gas-fired is marginal:											24,0
Average historical margin coal-fired (EURO/MWh)		19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5	19,5
Historical margin without switch (EURO mln/annum)		31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2	31,2
Margin after cost allowances (EURO/MWh)		19,5	18,3	17,0	15,0	15,0	16,9	18,6	16,9	16,9	16,9	16,9	16,9
Margin after cost allowances (EURO mln/annum)		31,2	29,2	27,2	24,0	21,3	24,0	26,4	24,0	24,0	24,0	24,0	24,0
Windfall margin (EURO/MWh)		0	-1,3	-2,5	-4,5	-4,5	-2,6	-0,9	-2,6	-2,6	-2,6	-2,6	-2,6
Totals for the two power plants				Before switch		After switch							
Margin after cost allowances (EURO mln/annum)		36,8	34,8	32,8	29,6	28,2	32,7	36,8	36,2	40,5	43,5	46,0	48,4
Historical margin without switch (EURO mln/annum)		36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8	36,8
Total fuel cost (EURO mln/annum)		55,6	55,6	55,6	55,6	58,7	58,7	58,7	58,7	58,7	58,7	58,7	58,7
Cost of allowances (EURO mln/annum)		0	0,4	0,9	1,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Windfall profits (EURO mln/annum)		0	-2,0	-4,0	-7,2	-8,6	-4,1	0,0	-0,7	3,7	6,7	9,2	11,6
Windfall profits (%)		0%	-5%	-11%	-20%	-23%	-11%	0%	-2%	10%	18%	25%	32%
Windfall profit (€/MWh)		0	-0,8	-1,7	-3,0	-3,6	-1,7	0,0	-0,3	1,5	2,8	3,8	4,8
Average price: margin + cost of fuel + allowances (€/MWh)		38,5	37,9	37,2	36,2	36,2	38,1	39,8	39,5	41,3	42,6	43,6	44,6
Higher price of electricity by emissions trading (€/MWh)		0	-0,7	-1,3	-2,3	-2,3	-0,5	1,3	1,0	2,8	4,1	5,1	6,1
Higher fuel cost by emissions trading (€/MWh)		0	0	0	0,0	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1,3
Higher cost of the allowances by Emissions trading (€/MWh)		0	0,2	0,4	0,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Average market demand (MWe)		300	300	300	300	300	300	300	300	300	300	300	300
Total cap of historical emission (kton CO2/annum)	95%	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703
Total emission (kton CO2/annum)		1793	1793	1793	1793	1703	1703	1703	1703	1703	1703	1703	1703
Total shortage (kton CO2/annum)		90	90	90	90	0	0	0	0	0	0	0	0

Observations:

- The PSR is calculated to be 0.71 ton CO_2/MWh in order to achieve the carbon constraint of 95% reduction of emissions.
- At the fuel switch level of € 17.9/ton CO_2, windfall profits are in first instance negative as under auctioning. Electricity prices are then lower than without emissions trading.
- With the same extra margin of € 1.9/MWh as under auctioning, the coal-fired plant will be willing to lower production and to maintain the total gross margin as before fuel switch. The electricity price is then still lower as without emissions trading.
- At the slightly higher extra margin of € 3.6/MWh, the windfall profit is again zero and the total gross margins of both plants are higher than before fuel switch. This situation causes a slight increase of the electricity price of € 1.3/MWh. This is much lower than the higher price under cap & trade (case C) of € 12.3/MWh.
- At higher CO_2-prices, which might occur if more fuel switch is needed, the electricity price increase is still modest if compared to cap & trade.
- What will actually happen in the market is as under auctioning determined by competition, the extra margin of € 1.9/MWh is expected as a minimum.

X.5 A further outline of the PSR approach

Following benchmark formula will serve the purpose of avoiding competitive distortions, of achieving an effective trading scheme with unambiguous signals. It takes BAT into account and the potential of processes to near, equal or surpass BAT. (BAT in this context meant as the proven Best Practice).

- **Benchmark data: population under the scheme**
    - Currently EU-25, in future with Norway, Canada, Japan, South Korea, etc.
    - An option is to apply different PSRs for different regions, e.g. EU-25, Americas (USA, Canada), China, India, etc. as a transition for 10-20 years.

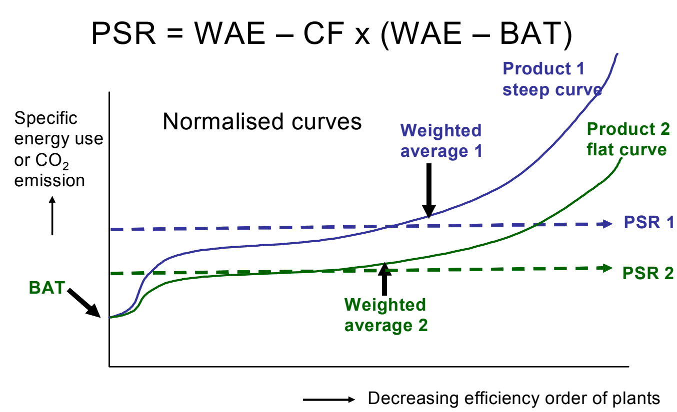
- **PSR = WAE – CF x (WAE – BAT)**
    - WAE = Weighted Average Efficiency
    - BAT = Best Available Technique (the proven Best Practice)
    - CF = Compliance Factor, equal for all PSRs, reflecting equal efforts between different types of installations[20].

- **Compliance Factor**
    - 2008: CF = for example 3% to create a CO_2 market price
    - 2012: possibly 15%-25%[21]
    - CF will be adjusted annually, for the years to come.

The annual adjustment of the Compliance Factor takes into account:

1. A market price for allowances at a level, which encourages innovations and efficiency improvements; this gives predictability for investors to reduce emissions.
2. Total industrial emissions and the long-term objective function for industrial emissions as established by the competent authorities.

The formula takes account of different shapes of the efficiency curve for different products (the potential of processes in their path to BAT[22]):



Products with a steep curve have a higher potential to reduce emissions, products with a flatter curve have a lower potential.

By gradually increasing the CF the demand on all products is increased. Nevertheless it should be noted that achieving BAT for an entire population takes a long time. During this time the BAT tends to improve. BAT is a moving target.

The proposed approach provides unambiguous signals to producers:

- Efficiency improvement will always be rewarded;
- It is also rewarding to improve BAT, which is an important climate objective.

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[20] To maintain the principle of equal effort between PSR's, regular up-dating of a PSR is required. With time, when the monitoring procedures under ETS are in place fully, the update of a PSR can become an annual, administrative routine.

[21] The stringency of the CF is within the limits of lead-time to reduce emissions a political decision; it depends also on the efforts undertaken elsewhere in the world.

[22] Therefore PSR = BAT + x% or PSR = average efficiency – y% are both unjust.

The certainty of the environmental outcome is ensured by the above mentioned annual adjustments of the CF and can be further supported by a contingency reserve. The combination of both approaches is outlined below:

- A key feature of this method is that the PSR will be adjusted annually: such adjustments are relatively small and are always done for future years. This is necessary when the economic growth (and hence emissions) is higher than expected beforehand and to compensate for the lower availability of hydropower in dry years.
- An additional recommended option is to set the PSR with an EU contingency reserve of 1%-1.5% (about 20-30 Mton/year), which is taken into account when establishing the new Compliance Factors for the future years. This contingency would be 100-150 Mton for the whole trading period. Before the last two years of the period, the contingency is therefore in practice only 0.4%-0.6%, much smaller than the reserves for new entrants. In this way the deviation with an ex-ante cap is very small, so virtually negligible. Furthermore, any surplus of the contingency should be banked to the next trading period.
- This means that the environmental result can be achieved equally as if under auctioning.

X.6 How to reduce emissions with PSR: the example of electricity

Around 2007 the average emission of fossil-fuelled electricity within the EU-25 is estimated to be about 700 kg CO_2/MWh. The Best Practice is around 250 kg CO_2/MWh (CHP). By 2015 or some years earlier the Best Practice will be zero kg CO_2/MWh for zero emission power plants. The use of the presented PSR formula enables and encourages this development.

With this approach CHP will bridge the gap until clean coal and gas plants are available. Schematically it is shown below how emissions can be lowered for electricity with PSR under ex-post control while the demand for electricity increases (estimations for EU-25):

Forecast EU-25	2002		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Coal with BAU MWe prod.	100.530	0,50%	86.027	86.457	86.889	87.324	87.760	88.199	88.640	89.083	89.529	89.976	90.426
Co-firing biomass penetration				1,0%	3,0%	5,0%	7,0%	9,0%	11,0%	13,0%	15,0%	18,0%	20,0%
Possible reduction co-firing biomass		Mton CO2	0,94	-7	-21	-36	-51	-65	-80	-95	-111	-133	-149
Co-firing biomass increase as from 2008				865	2.607	4.366	6.143	7.938	9.750	11.581	13.429	16.196	18.085
Normal coal & lignite excl. biomass			86.027	85.592	84.282	82.957	81.617	80.261	78.890	77.502	76.099	73.780	72.341
Gas incl. CHP	60.318	3,7%	90.753	94.110	97.592	101.203	104.948	108.831	112.858	117.034	121.364	125.854	130.511
Oil	20.106	0,3%	20.409	20.471	20.532	20.594	20.655	20.717	20.780	20.842	20.904	20.967	21.030
Subtotal fossil-fuelled electricity in MWe			**197.189**	**201.038**	**205.014**	**209.121**	**213.364**	**217.747**	**222.277**	**226.959**	**231.797**	**236.798**	**241.967**
Nuclear (Finland + capacity cree|	107.232	0,50%	111.038	111.594	112.151	112.712	113.276	113.842	114.411	114.983	115.558	116.136	116.717
Renewables	43.563	3,0%	53.001	54.591	56.229	57.916	59.653	61.443	63.286	65.185	67.140	69.155	71.229
Other	3.351	0,0%	3.351	3.351	3.351	3.351	3.351	3.351	3.351	3.351	3.351	3.351	3.351
Total MWe production	**335.101**		**364.579**	**370.574**	**376.745**	**383.100**	**389.644**	**396.384**	**403.326**	**410.478**	**417.846**	**425.439**	**433.264**
Growth				1,64%	1,67%	1,69%	1,71%	1,73%	1,75%	1,77%	1,80%	1,82%	1,84%

				Second trading period					Third trading period				
		2002	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Total MWe in fossil incl. biomass		180.954	197.189	201.038	205.014	209.121	213.364	217.747	222.277	226.959	231.797	236.798	241.967
Total TWh in fossil incl. biomass		**1.585**	**1.727**	**1.761**	**1.796**	**1.832**	**1.869**	**1.907**	**1.947**	**1.988**	**2.031**	**2.074**	**2.120**
BAT (Best Practice)	ton / MWh		**0,25**	**0,25**	**0,25**	**0,25**	**0,25**	**0,25**	**0,25**	**0**	**0**	**0**	**0**
WAE	ton / MWh		**0,69**	**BAT = Combined Heat & Power**						**BAT = Zero emission plants**			
CF (Compliance Factor)			0%	**4%**	**9%**	**15%**	**21%**	**27%**	**31%**	**22%**	**25%**	**28%**	**31%**
PSR = WAE - CF x (WAE - BAT)		**0,750**	**0,69**	**0,67**	**0,65**	**0,62**	**0,59**	**0,57**	**0,55**	**0,54**	**0,51**	**0,49**	**0,47**
Total cap = emission (Mton) of PSR		**1.189**	**1.185**	**1.177**	**1.161**	**1.137**	**1.111**	**1.084**	**1.072**	**1.064**	**1.045**	**1.024**	**1.003**
Reduction in Mton				**-8**	**-23**	**-48**	**-74**	**-101**	**-112**	**-121**	**-140**	**-160**	**-182**
Average trading period reduction in Mton/annum						**-51**					**-143**		

In this approach it is assumed and recommended that co-firing biomass in power plants is stimulated (which is not the case in current grandfathering methods). It is a clear possibility to lower long cycle emissions of new and – this is important from a policy point of view – existing power plants. The penetration of co-firing biomass at the top of the table is just an example to show what impact this possibility can have. Under PSR with ex-post control the market will decide for the lowest cost options (CHP, biomass, zero emission plants).

X.7 PSR stimulates efficiency improvement

In an efficiency-based system, there are no opportunity-costs and an efficiency improvement will lower the real cost more than the fuel cost decrease. In contrast with cap & trade, the system of PSR is very stimulating to improve the efficiency of power plants.

The earlier mentioned 2nd effect (that lowering costs for a marginal plant lowers the profit of all plants in operation with lower marginal costs) may still be there, but is less likely to occur. Competition based on efficiency is encouraged and winners of market share are not hampered (in contrast with cap & trade). Not investing in efficiency means that competitors may do, which can lead to a loss of market share.

X.8 Objections raised against PSR with ex-post control

In economic literature various objections are mentioned. In the recent study[23] of ECN a list is provided. These objections are presented and discussed hereunder.

"A relative quota system is less efficient because it is a combination of a price on emissions and a production subsidy. Consequently, production will exceed the optimal output level, and allowance price and abatement costs need to be higher in order to meet the same emission target as in an efficient system with absolute quota (Koutstaal, et.al., 2002; Koutstaal, 2002)"

Comments:

- The price-elasticity of the demand for electricity is low for consumers but indeed high for industrial users of electricity (e.g. aluminium, electrolysis, etc.). This leads to a severe loss of competitiveness and at higher CO_2-prices closing down of intensive electricity users while production is shifted outside the EU ("leakage of emissions"). But this effect is not in agreement with a contribution of the EU to the global climate problem and the intentions of the Directive (recital 3).
- If cap & trade would be globally applied then the leakage problem will not occur. But in this case the price-elasticity of the demand for electricity is rather low for all users.
- In addition, cap & trade has fundamental drawbacks if compared to PSR:
    - It hinders innovative winners of market share with lower emissions per unit of product.
    - Efficient and innovative new entrants are faced with the uncertainty of the availability of allowances from a limited reserve (can be depleted), which hinders the introduction of efficient and innovative technologies.
    - Lower emissions become in the future part of the historical reference for the amount of allowances for a future trading period. As updating is in practice inevitable under a cap & trade approach, the effectiveness of the scheme is undermined.
- The latter arguments are usually not taken into account in economic literature.
- In conclusion, PSR is not inferior but superior to a system with absolute quotas.

"A relative quota system does not provide certainty with regard to the environmental effectiveness of an EU ETS and may lead to an overrun of international commitments on carbon mitigation or the need to take additional (more expensive, short-term) measures to meet these commitments. To some extend, this problem can be controlled by a regular adjustment of the PSR, but this creates uncertainty in the carbon and products markets".

Comments:

The issue of certainty of the environmental outcome is extensively elaborated in the already mentioned recent report of this author[24]. In short following observations are reiterated:

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[23] "CO_2 price dynamics: the implications of EU emissions trading for the price of electricity", ECN. J. Sijm, S. Bakker, Y. Chen, H. Harmsen and W. Lyse, September 2005.

[24] "Climate change challenges and the search for a sustainable policy", V. Schyns, 21 June 2005.

- There is also no certainty of the outcome in cap & trade if the imposed ex-ante cap appears ex-post to be too stringent (for example by higher economic growth). If only applied in the EU certainty is high for the EU but then certainly leakage occurs.
- There is also no certainty of the outcome for all sectors outside the EU ETS.
- The problem of a higher than expected production can be solved to a large extent (so not to "some" extent) by adjusting the PSR annually, for the future years to come. The error at the end of a trading period would be very low, certainly if the suggested contingency reserve is taken into account.
- The long-term efficiency and effectiveness of PSR is not worse but much better than systems based on current cap & trade allocation rules (see also comments on the first objection and the study of the footnote below).
- This is a remarkable conclusion. Under cap & trade a static view of the market is assumed while under the dynamic view of PSR competition is enhanced; frontrunners are rewarded unambiguously when they undertake to invest in higher efficiency or novel technologies.

"A relative quota system does not fit into the present Directive (and political consensus) on the EU ETS – opting for a fixed cap & trade system, at least up to 2012 – and, hence it may take years (if ever) to change the fundamentals of the EU ETS".

Comments:
Why PSR is possible within the current Directive is elaborated as well in the mentioned recent report (see footnote below). In short following findings are reiterated:

- It is demonstrated that cap & trade shows fundamental shortcomings to the requirements of the Directive. Therefore cap & trade cannot be regarded as a correct implementation of the Directive.
- The German government did not accept the prohibition of the Commission for ex-post corrections and went to the Court of First Instance in Luxembourg (while applying ex-post until it would be legally forbidden). It is claimed that the Directive does not forbid the German ex-post control[25]. The mentioned report argues that any ex-post is possible within the Directive, allowances are given conditionally[26]. The condition is that the forecasted production is met.
- There is a growing consensus that the current allocation rules are not acceptable anymore, they are not fit for purpose and lead to numerous distortions such as the windfall profits for electricity producers. For example, the Environmental Committee of the European parliament has recognised the flaws of historical grandfathering. And in 2005 DG Environment has stated, "the next step [for post 2012] must be bold". Furthermore, the new German government has decided that the windfall profits issue must become resolved, and this is by definition not possible with frozen ex-ante caps.

- Why wait for 2013 if the fundamental problems are becoming clear already within a year after the start of the scheme. Anyhow, the electricity problem is urgent and must therefore be solved in the short-term, within the 1st trading period.

[25] In the German ex-post control for new entrants allowances need to be given back when the production is lower than forecast, but there are no additional allowances if the realised production is higher than forecast; for incumbents this principle is only applied if the production decreases below 60% of the production of the reference period, which is an arbitrary and not a logical threshold).
[26] For example Annex III (10) reads: “The plan shall contain a list of the installations covered by this Directive with the quantities of allowances <u>intended</u> to be allocated to each.” This intention is also mentioned in article 9 and article 11 speaks about “… initiate the process of allocation to the operator of each installation.”

"A relative quota system may imply high information and other transaction costs, notably of a large number of PSRs has to be determined and regularly updated for a large number of firms and/or products, including process emissions. It may be cumbersome and time-consuming to determine EU-wide PSRs or to find a political consensus on what an acceptable, average EU benchmark should be (Renaud, 2004; CEPS, 2005). Moreover, even if a relative quota system based on EU-wide PSRs could be developed and agreed on, it still may distort the competitiveness among firms (Jansen, 2002; Elzenga and Oude Lohuis, 2003)".

Comments:
The transaction costs of PSR and the problem of establish EU-wide average PSRs are also elaborated in the mentioned recent report. This often heard statement is not based on factual research. In short following findings are reiterated:

- Transaction costs are contrary to conventional wisdom very low. Dutch companies have extensive experience with benchmarking under the Covenant Benchmarking. The problem with benchmarking on a worldwide scale is participation. This will be no problem for application of PSRs within the EU as companies would be requested to submit data. Some running benchmarks have already a high degree of participation within the EU. For example EU-wide PSRs for refineries and steamcrackers take hardly any cost and can be made available within for example a few weeks.
- The determination of a uniform EU-wide PSR for electricity is relatively easy because the products electricity and heat (for CHP) are fully defined and straightforward. The emissions will be known soon (for 2005 by May 2006) with a better accuracy than ever. An effort of only 1-2 calendar quarters is needed to establish the EU-wide PSR.
- The PSR method can commence with a relatively low number of products, which account for a high percentage of the total emissions. Gradually this approach can be extended.
- Distortions among firms: cost-price differences will be different if compared to the situation without emissions trading. This would happen as well when auctioning would be applied as advocated by the authors of the ECN report which raised these objections. If these "distortions" are not acceptable then the EU ETS and efforts to lower emissions with other measures should be abandoned. Anyhow, with PSR electricity producers have exactly the same cost-price difference as under auctioning and on the short-term or with long-term investment planning companies have the possibility to match their competitors.

"A relative quota system is faced by the same trade-off as a grandfathering system depending on whether it leads to the full internalisation of external cost in outlet prices or not, i.e. a trade-off between environmental and social efficiency on the one hand and higher prices for consumers and resulting windfall profits on the other hand".

Comments:
The mentioned trade-off is quite different for PSR compared to cap & trade.

- In cap & trade indirect effects such as notably the efficiency of the use of electricity are not taken directly into account by the cap, but through the internalisation of the CO_2-price in the electricity price (also leading to windfall profits as mentioned correctly). Otherwise switching for example from gas (for heating) and steam (for steamturbines) to electricity could be done without punishment; this would be a leakage in the system.
- But the authors of the ECN report do not advocate cap & trade, they propose auctioning as a better system. Auctioning is indeed a feasible solution, but only if applied globally.
- PSR works similar as auctioning and differently if compared to cap & trade; the efficiency of the use of electricity is taken into account. This is the standard way of determining benchmarks by competent consultancy companies.
- The absence of internalisation of the CO_2-price in the electricity price by the PSR method is therefore in itself no contradiction with the internalisation under cap & trade.

X.9 Competitive consequences of PSR for electricity producers

Producers with a larger than average share of gas-fired power plants will receive more allowances than needed while the opposite is true for producers with a higher share of coal and/or lignite power plants.

This is a consequence of the carbon constraint. It makes clear in what directions electricity producers must move: to higher efficiency, to lower carbon emissions, also by fuel switch.

Certainly, the comfortable position with windfall profits under cap & trade will disappear with PSR. Producers with a higher share of coal and/or lignite power plants will lose market share to gas-fired plants, but the market needs their electricity in the foreseeable future. Opportunity-costs are turned into hard costs, and therefore these costs will be reflected in the electricity price.

The share of electricity from coal/lignite and gas is not determining the cost effects of PSR; it is the electricity price effect of the annual share of the marginal plants within Member States. The earlier table is therefore repeated (source: Energy Focus Electricity, estimates on personal authority by Franck Schuttelaar, Gaselys, September 2005; Netherlands estimate V. Schyns):

Type of plant	Emission factor Ton CO_2/MWh	Marginal dispatch period (annual %)			
		Germany	France	UK	Netherlands
Nuclear	0	-	34%	-	-
Lignite	1.1[27] (source PWC)	15%	-	-	-
Coal	0.9	60%	57%	18%	50%
Gas	0.4	25%	-	82%	50%
Fuel oil	0.85	-	9%	-	-
Average marginal ton CO_2/MWh		**0.81**	**0.59**	**0.49**	**0.65**

RWE is reported[28] to have the highest emission per MWh in Europe (707 kg CO_2/MWh in 2001). RWE relies for 2/3 on coal and lignite. In the German market coal and lignite power plants are marginal 75% annually. During this time German producers including RWE will incorporate the higher cost caused by one uniform PSR into the price of electricity.

The application of one uniform PSR is partly also a psychological problem. With auctioning it is felt that the financially strong German producers have adequate power to ensure that they have enough allowances to be able to produce. With one uniform PSR it is often mentioned (to this author) that coal- and lignite-fired power plants are "out of the business". The real comparison is illustrated in the table below (data just for illustration):

	Cap & trade	Auctioning	PSR
Assume EU cap	-5%	-5%	-5%
Assume fuel switch 1st instance	-50 Mton/year	-50 Mton/year	-50 Mton/year
Electricity price increase	High	High	Close to zero
Windfall profits Germany	High	Low	Close to zero
Stimulation of efficiency	Ambiguous/poor	Unambiguous	Unambiguous
Leakage of emissions outside EU	Base case	Same	Very low / zero
Fuel switch 2nd instance (estimated)	**-50 Mton/year**	**-40 Mton/year**	**-50 Mton/year**
Loss market share coal/lignite	**Base case**	**Less**	**Same**

The crucial security of outcome (the cap) is the same under any system. The loss of market share depends on the cap and not on the system applied. Therefore, the transition to lower carbon emissions must be planned carefully; the cap must go down gradually and orderly

[27] Franck Schuttelaar used 0.9 ton CO_2/MWh.
[28] "Climate change and the power industry", presentation by PriceWaterhouseCoopers, October 2002.

(political decision). The cap must also take into consideration that real abatement efforts are not (yet) in place in other important areas in the world, e.g. USA, China and India.

Under PSR this transition will be effective because efficiency is unambiguously stimulated. And important for electricity users, electricity prices hardly increase with PSR.

To illustrate this, the German market is considered with the same simple model of the two power plants, but now with the coal-fired plant marginal 75% annually:

PSR
(Performance Standard Rate)
Higher price differential
coal - gas

Full delivered fuel prices	€/GJ	
Coal	1,8	38%
Gas	4,7	

Cheapest More expensive
MPCM = Market Price at Competitive Margin

PSR		Competitive				CO_2-price (EURO/ton)				A	1,9	2,1	B	Extra margins			
ton CO2		gross			Fuel cost	0	5	10	17,9	17,9	17,9	17,9	25	33,9	40	45	50
per MWh		margins		ton CO_2	€/MWh				Before switch	After switch							
	Technology	€/MWh	Efficiency	per MWh		MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM	MPCM
0,71	CCGT average	7,0	49%	0,41	34,5	41,5	40,0	38,6	36,2	36,2	38,1	38,3	36,0	33,3	31,5	30,0	28,5
0,71	Coal average	15,0	37%	0,91	17,5	32,5	33,5	34,6	36,2	36,2	38,1	38,3	39,5	41,3	42,6	43,6	44,6
Market price at high demand (€/MWh)					25%	41,5	40,0	38,6	36,2	36,2	38,1	38,3	39,5	41,3	42,6	43,6	44,6
Market price at low demand (€/MWh)					75%	32,5	33,5	34,6	36,2	36,2	38,1	38,3	39,5	41,3	42,6	43,6	44,6
Gas-fired power plant					MWe:	100	100	100	100	122	122	122	122	122	122	122	122
Emission (kton CO2/annum) assume 8000 hrs/year						330	330	330	330	403	403	403	403	403	403	403	403
Allowances = realised production x PSR (kton CO2/annum)						568	568	568	568	694	694	694	694	694	694	694	694
Shortage of allowances (kton CO2/year)						-238	-238	-238	-238	-291	-291	-291	-291	-291	-291	-291	-291
Cost of allowances (EURO mln/annum)						0	-1,2	-2,4	-4,3	-5,2	-5,2	-5,2	-7,3	-9,9	-11,6	-13,1	-14,6
Assume historical margin (EURO/MWh)						7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0
Historical margin without switch (EURO mln/annum)						5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6
Margin after cost allowances (EURO/MWh)						7,0	7,0	7,0	7,0	7,0	8,9	9,1	12,4	16,9	20,0	22,5	25,0
Margin after cost allowances (EURO mln/annum)						5,6	5,6	5,6	5,6	6,8	8,7	8,9	12,2	16,5	19,5	22,0	24,4
Windfall margin (EURO/MWh)						0	0,0	0,0	0,0	0,0	1,9	2,1	5,4	9,9	13,0	15,5	18,0
Coal-fired power plant					MWe:	200	200	200	200	178	178	178	178	178	178	178	178
Emission (kton CO2/annum) assume 8000 hrs/year						1463	1463	1463	1463	1300	1300	1300	1300	1300	1300	1300	1300
Allowances = realised production x PSR (kton CO2/annum)						1136	1136	1136	1136	1009	1009	1009	1009	1009	1009	1009	1009
Shortage of allowances (kton CO2/year)						328	328	328	328	291	291	291	291	291	291	291	291
Cost of allowances (EURO mln/annum)						0	1,6	3,3	5,9	5,2	5,2	5,2	7,3	9,9	11,6	13,1	14,6
Assume historical margins depending on market place						Gross margin gas-fired:				7,0	Gross margin coal-fired when marginal:						15,0
Indication Germany:			25%	75%	Gas / coal	Gross margin coal-fired when gas-fired is marginal:											24,0
Average historical margin coal-fired (EURO/MWh)						17,3	17,3	17,3	17,3	17,3	17,3	17,3	17,3	17,3	17,3	17,3	17,3
Historical margin without switch (EURO mln/annum)						27,6	27,6	27,6	27,6	27,6	27,6	27,6	27,6	27,6	27,6	27,6	27,6
Margin after cost allowances (EURO/MWh)						17,3	16,6	16,0	15,0	15,0	16,9	17,1	16,9	16,9	16,9	16,9	16,9
Margin after cost allowances (EURO mln/annum)						27,6	26,6	25,6	24,0	21,3	24,0	24,3	24,0	24,0	24,0	24,0	24,0
Windfall margin (EURO/MWh)						0	-0,6	-1,3	-2,3	-2,3	-0,4	-0,2	-0,4	-0,4	-0,4	-0,4	-0,4
Totals for the two power plants									Before switch	After switch							
Margin after cost allowances (EURO mln/annum)						33,2	32,2	31,2	29,6	28,2	32,7	33,2	36,2	40,5	43,5	46,0	48,4
Historical margin without switch (EURO mln/annum)						33,2	33,2	33,2	33,2	33,2	33,2	33,2	33,2	33,2	33,2	33,2	33,2
Total fuel cost (EURO mln/annum)						55,6	55,6	55,6	55,6	58,7	58,7	58,7	58,7	58,7	58,7	58,7	58,7
Cost of allowances (EURO mln/annum)						0	0,4	0,9	1,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Windfall profits (EURO mln/annum)						0	-1,0	-2,0	-3,6	-5,0	-0,5	0,0	3,0	7,3	10,3	12,8	15,2
Windfall profits (%)						0%	-3%	-6%	-11%	-15%	-2%	0%	9%	22%	31%	38%	46%
Windfall profit (€/MWh)						0	-0,4	-0,8	-1,5	-2,1	-0,2	0,0	1,2	3,0	4,3	5,3	6,4
Average price: margin + cost of fuel + allowances (€/MWh)						37,0	36,8	36,6	36,2	36,2	38,1	38,3	39,5	41,3	42,6	43,6	44,6
Higher price of electricity by emissions trading (€/MWh)						0	-0,2	-0,5	-0,8	-0,8	1,1	1,3	2,5	4,3	5,6	6,6	7,6
Higher fuel cost by emissions trading (€/MWh)						0	0	0	0,0	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1,3
Higher cost of the allowances by Emissions trading (€/MWh)						0	0,2	0,4	0,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Average market demand (MWe)						300	300	300	300	300	300	300	300	300	300	300	300
Total cap of historical emission (kton CO2/annum)					95%	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703
Total emission (kton CO2/annum)						1793	1793	1793	1793	1703	1703	1703	1703	1703	1703	1703	1703
Total shortage (kton CO2/annum)						90	90	90	90	0	0	0	0	0	0	0	0

Observations valid for the German market:

- Without emissions trading, the secondary windfall profit for coal- and lignite-fired plants when gas-fired plants are marginal is lower in Germany (gas is only marginal 25% annually).
- At the minimum fuel switch price of € 38.1/MWh the electricity price is € 1.1/MWh higher than without emissions trading.
- Windfall profits are then -2% if compared to -11% when coal-fired and gas-fired plants are both marginal 50% annually as in the previous table.
- The lower gross margin for the coal-fired plant is therefore only € 0.4/MWh lower than without emissions trading (€ 17.3/MWh - € 16.9/MWh).
- In addition, RWE and others also have nuclear capacity still making a small secondary windfall profit of € 1.1/MWh <u>annually</u> in the presented example.

- Therefore in practice, the latter two effects compensate the additional costs for electricity producers with a relative high share of coal and lignite.

Probably RWE and others also have gas-fired power plants and an interest to invest more in CHP. All these factors mean that there are no major costs related to the introducing of one uniform PSR for electricity producers with a high share of coal or lignite.

X.10 PSR for electricity and frictions with the Burden Sharing Agreement

PSR leads to different allocations for individual installations if compared to current allocation rules. Of course, when the present fundamental problems need to be solved, allocations must be different.

One consequence is that Member States with a relatively larger share of gas-fired power plants will need to grant more allowances than today (e.g. UK, Netherlands). And other Member States with a higher share of coal and/or lignite will need to grant fewer allowances (e.g. Germany). This effect is estimated in the following table for the situation in a few Member States for the 1st emissions trading period 2005-2007 (source: Energy Focus Electricity, estimates on personal authority by Franck Schuttelaar (with support from Point Carbon), Gaselys, September 2005; Netherlands estimate V. Schyns):

	Germany	France	UK	Netherlands
Total electricity generation in TWh	560	540	398	100
Fossil-fuelled electricity (table in IV)	64%	10%	78%	94%
Fossil-fuelled electricity in TWh	**358**	**54**	**310**	**94**
Emissions in Mton CO_2	324	52	179	About 50
Allowance deficit Mton CO_2	11	8	48	1.5-2
Allowance deficit % of emissions	3.5%	15%	27%	3%-4%
Allowances granted in Mton	313	44	131	46
Allowances granted ton CO_2/MWh fossil	0.87	0.82	0.42	0.49
Assume uniform PSR fossil	**0.70**	**0.70**	**0.70**	**0.70**
Deviation of current allocation Mton	**-61**	**-6**	**+99**	**+20**

This may be perceived as a problem because the Burden Sharing Agreement is a legal obligation[29] for Member States as well. At current prices for allowances this would be a costly adaptation. Various solutions are proposed in the next two sections.

X.11 Regional electricity PSR: intermediate option to frictions

A first possibility of the PSR method for Member States with a relatively larger (or smaller) share of gas-fired power plants is to apply a regional PSR. This can only be done if the electricity transport capacity of that region with the remainder of the EU is rather low.

An example could be the UK. The PSR could be set lower (below the average emission of the UK). This mitigates the friction with the burden sharing agreement as mentioned above.

The switch prices in the UK and the rest of the EU are exactly the same provided the plants with the same carbon efficiency are executing the fuel switch.

When adopting a regional PSR, the PSR for the remainder of the EU needs to be recalculated. Otherwise the balance is disturbed and the shortage of allowances is getting too small to obey the desired cap or too high to overcome in the market on the short-term.

[29] This legal obligation may be on the same or on a different level than the Directive.

X.12 PSR and a solution to frictions with the Burden Sharing Agreement

Apart from regional PSRs, there is another straightforward simple solution, a total solution without cost.

The Member States are currently undertaking to make the new National Allocation Plans (NAPs). The new caps are almost known or will be known within a relatively short timeframe from now.

The solution is to create an "Equalisation Fund". Member States that intended to grant more allowances than under PSR put their surplus in this fund. Member States, which need to grant more allowances, are fully compensated by additional allowances from this fund.

The total amount of allowances in the EU will by definition be the same if the environmental constraint is the same. So a solution is possible with hardly any effect for electricity users between different Member States and no effect between Member States themselves under the Burden Sharing Agreement.

X.13 Conclusions PSR

- PSR with ex-post control gives a market functioning, which is equal to auctioning.
- A key feature of this method is that the PSR will be adjusted annually: such adjustments are relatively small and are always done for future years. This is necessary when the economic growth (and hence emissions) is higher than expected beforehand and to compensate for the lower availability of hydropower in dry years.
- An additional recommended option is to set the PSR with a contingency reserve of 1%-2% (about 20-40 Mton/year), which is taken into account when establishing the new Compliance Factors for the future years. This contingency would be 10-20 Mton/year in the beginning of the trading period, so 50-100 Mton for the whole trading period. Before the last two years of the period, the contingency is therefore in practice only 0.4%-0.8%. In this way the deviation with an ex-ante cap is very small, so virtually negligible.
- Furthermore, any surplus of the contingency should be banked to the next trading period.
- This means that the environmental result can be achieved equally as if under auctioning. Please note that auctioning is the undisputed allocation system to achieve the environmental result.
- Under PSR the average electricity market prices are hardly or not affected and the issue of windfall profits is (virtually) solved. There are no negative effects of emissions trading for sectors under the scheme as well as for sectors outside the scheme (e.g. aluminium).
- Under PSR efficiency and innovation are unambiguously stimulated. CHP and zero emission power plants are structurally supported as under auctioning.
- The leakage problem of cap & trade is virtually eliminated.
- PSR (as auctioning) is compatible with the competition rules of the EC Treaty.
- PSR complies with the polluter-pays principle for producers.

It is important that the cap for the 2nd trading period is not too stringent, in order to facilitate a smooth and realistic transition towards lower emissions.